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A MANUAL OF PATHOLOGY

A MANUAL
OF
PATHOLOGY

BY
JOSEPH COATS, M.D.
LATE PROFESSOR OF PATHOLOGY IN THE UNIVERSITY OF GLASGOW

FIFTH EDITION, REVISED THROUGHOUT BY
L. R. SUTHERLAND, M.B.
PROFESSOR OF PATHOLOGY IN THE UNIVERSITY OF ST. ANDREWS

WITH SEVEN HUNDRED AND TWENTY-NINE ILLUSTRATIONS
AND TWO COLOURED PLATES

LONGMANS, GREEN, AND CO.
39 PATERNOSTER ROW, LONDON
NEW YORK AND BOMBAY
1903

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PREFACE TO FOURTH EDITION.

A DESIRE has been expressed that this posthumous edition of the late Professor Coats's standard work should contain some brief indication of what he did, and what he was, in a life-time full of activity, but too short according to our human estimate for the tasks allotted to it. No more pathetic instance of frustrated hopes could well be found than in the simple statement that Joseph Coats, working all his life for nearly a quarter of a century towards a professorship of pathology, should have attained that official status barely five years before his death, and should have inaugurated a new pathological institute, mainly due to his own initiative and enthusiastic endeavours, on October 14th, 1896, to be used for only three seasons under his direction, amid periods of ill-health, which ended in a fatal result on January 24th, 1899. The life that was thus closed, however, was one of remarkably sustained effort, and of absolute consistency of aim, from first to last. For more than twenty years before he became a professor in the University, Dr. Coats was the mainstay of scientific pathological teaching in Glasgow. All his attainments, and all his resources, were devoted consistently, and with marked success, to this one object; and the present volume, as well as the completed pathological institute which is now carried on by his successor, form the more or less permanent memorials of a life-time of arduous labour, carried on among the students of Glasgow University, by one who was as much respected by them as he was by those who later on became his colleagues in an official sense. As the oldest of these, a friend of Dr. Coats from his studentship onwards, and at all times working in co-operation with him, I have been asked to write these few lines as a preface to his book. A more detailed notice of the man will be found in the *British Medical Journal* for 4th February, 1899. Here it is sufficient to recall in a few sentences what has a direct bearing on the present undertaking.

Dr. Coats, as a teacher of pathology in its modern aspects, was methodical, painstaking, and thorough in all his ways. At an early

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period he had studied both in France and Germany under the best teachers, and had adopted everything as regards their methods of procedure which he regarded as conducive to the highest success. He became pathologist, first to the Royal Infirmary, and afterwards to the Western Infirmary; where, although his position was not that of a professor till 1894, his supremacy was unquestioned, and he had the countenance and support of the University long before he became a professor *de facto*. Thus it happens that this volume, the first edition of which appeared in 1883, was even at that time directed carefully and practically to the end which it was destined to fulfil, by becoming at once a manual of instruction for the student of medicine, and a work of reference for the practitioner who may be desirous of keeping his pathological knowledge up to date. Until the author was disabled by illness it may fairly be said that not a single session passed without the entire teaching of the book being gone over and mentally reviewed in the light of new and original research. For Dr. Coats's mind, if one may admit that it fell short of the highest type of creative originality, was eminently receptive, full of sustained enthusiasm, and always directed to the verification by his pupils, as well as by his own exertions, of everything new that appeared to be worthy of renewed research. The abundance of materials at his disposal was such that, with systematic and practical classes of undergraduates, and latterly post-graduate classes conducted in the autumn, his time was very fully taken up, and his attention constantly kept alive to all the details of modern pathology. The writer of these lines, being himself a pathologist of older date, and ever interested in the subject, can bear witness from experience on many occasions how full and how fresh was the impulse that always came from conferring with Dr. Coats on any subject arising within the department of scientific pathology. Nor was the clinical interest ever lost sight of by Dr. Coats. Early in his career he had seen a great deal of practice in the wards; and in the Clinical and Pathological Society of Glasgow, of which he was one of the original members, the habit of regarding pathological facts from the clinical side was kept up; the greatest pains being taken to make the reports, and also the preparations in the museum, representative of both aspects of knowledge. So that I apprehend that this volume, far more than most treatises on Pathology, will be found to be full of suggestions for the busy man in the routine of daily practice.

Above all, I am confident that it will be found to represent adequately the existing state of pathological science in such a way as to be eminently trustworthy in detail. It will present many things in new lights, but always with most careful reference to investigations founded on fact. The lucid order and readableness, which were the characteristics of former editions, were never gained by over-indulgence in merely speculative considerations; and the illustrations, as well as the researches on which they are founded, are largely the result of personal and original research. The present edition may be said to have had the counsel and support of the late author up to the very close of his life; and it has been carried out by his late chief assistant, although with considerable necessary alterations, in the very spirit of the original work. It is the expectation, and must be the desire, of every friend of Professor Coats, and every member of the Glasgow medical school, that this work in its present form may be a worthy memorial of one who was respected and beloved alike by teachers and students.

W. T. GAIRDNER.

THE UNIVERSITY,
GLASGOW, *January*, 1900.

EDITORIAL NOTE TO FIFTH EDITION.

THROUGHOUT the revisal of this edition, the requirements of the student of medicine have been kept prominently in view. Considerable alterations have been made without materially interfering with the original plan or intention of the work. The chapter on Bacteriology has been omitted, as the subject is now one which can only be adequately dealt with in special treatises.

The illustrations have been increased from 490 to 729, and two coloured plates have been added. With few exceptions these have been made from specimens in the Pathological Museum of the University College, Dundee, and I desire to express my cordial thanks to Mr. Richard Muir, Edinburgh, Mr. H. C. Smith, London, and Messrs. J. B. Corr and George Fair, Dundee, for their painstaking and successful labours.

Prof. Kynoch, Dundee, has very kindly revised the section on Diseases of the Female Generative Organs, and I am under a heavy debt of gratitude to my colleague, Prof. C. R. Marshall, not only for the preparation of the index, but for many valuable suggestions and much assistance in seeing the work through the press.

L. R. SUTHERLAND.

UNIVERSITY COLLEGE,
DUNDEE, *Sept.* 1903.

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A MANUAL OF PATHOLOGY

A MANUAL OF PATHOLOGY.

INTRODUCTION.

PATHOLOGY (πάθος—disease, λόγος—a discourse) is the scientific study of disease. The term Disease, which strictly means nothing more than Discomfort, has reference primarily to the subjective sensations of the person affected, but as these feelings have an objective basis, and as it is possible to distinguish various groups of phenomena, each with its own mode of divergence from the healthy conditions, these groups of phenomena have come to be designated diseases.

In Pathology we aim at getting close to the various diseases, so as to study their essential nature, and determine their individual causes. It is a scientific study, and it is pursued by scientific methods. There are three principal methods by which the nature of disease is elucidated, as there are three main sources of our knowledge of disease. These may be designated respectively, Experimental Pathology, Pathological Anatomy and Histology, and Clinical Observation. To each of these is Pathology indebted in endeavouring to form a conception of each disease in its true characters.

So far as it can be prosecuted, Experimental Pathology, which aims at the production of morbid conditions in animals so as to observe them more closely, is calculated to afford us the most direct and trustworthy information regarding the nature of diseases, and much of the advance in modern pathology is due to this line of study. If we can actually induce a given disease in an animal, we already know a great deal in regard to its causation, and are in the way of finding out much as to its nature. In some cases we are able actually to observe the morbid processes, by means of the microscope or otherwise, in the living animal; in others we can kill the animal at various periods after the onset of the disease, and observe the results at various stages. We can vary the experiment in different ways so as to eliminate on one side and another the various elements, and so reduce the problem to its simple and necessary parts. Experimental pathology has thus carried us far towards understanding many of the conditions in disease. Reference need only be made to the reformations which this line of study has effected in our knowledge of Inflammation, Embolism, and Tuberculosis.

The study of Morbid Anatomy may not effect such revolutions in pathology as experimental pathology, but it is by this method that the scientific basis of pathology has been laid, and, in the training of the individual medical student, it is calculated to play a more important part in giving him an understanding of the nature of the diseases with which his professional work will afterwards bring him in contact. Morbid anatomy deals with the physical changes which disease produces in the body. These changes are, as it were, the expression of the pathological processes, and are only to be regarded as indications of the existence of these processes. It is probable that all morbid processes produce changes in structure, but the changes may sometimes elude our observation. For the most part, however, we are able to associate the change of structure with the morbid process, and the observed change leads us up to the actual nature of the disease.

Morbid Anatomy is the study of the structural changes in all periods and stages of the disease. It is sometimes objected to this mode of study, that in observing the state of the tissues after death we see only the last stages of disease, and in some cases only the results. This, however, is not the case. Every clinical observer will admit that in the same disease the fatal issue occurs, in different cases, under the most diverse circumstances. Death ensues, as a rule, when by reason of defective nutrition, or a deficiency in the supply of oxygenated blood, the essential functions of the body can no longer be carried on. As there is in different individuals an infinite variety in the vigour of the vital processes, so a condition which in one will very slightly affect the essential phenomena of life, will, in another, seriously compromise them. This is an experience of our every-day life. Hence it may be said in any given disease, the appearances after death will, in different cases, show diverse stages and phases of the disease. Indeed, even a single case may show, in different parts of the affected organs, the various changes in their different stages.

As an illustration of what is meant, take the case of pneumonia

-acute inflammation of the lungs. Patients die in this disease, as a rule, from failure of the heart and consequent cessation of the circulation; but the paralysis of the heart is not related mainly to the condition of the lungs. It is more closely related to the elevation of temperature and alteration of the blood which are the consequences of the absorption of poisonous products from the lungs, while the power of resistance of the heart in each person is an important element in the matter. And so it happens that one man will die with a limited and advancing pneumonia, while another will survive a very extensive involvement of the lung. The lung at death in the one case is in the same stage of the disease as in the other at a certain date during life. We can study the nature of the disease in the former and we are surely warranted in assuming that, in the patient who survived, the state of the lung is virtually identical with that in the patient who died.

Again, in a carcinoma growing up to death, we have, at the growing margins of the tumour, changes which are the same as those by which the tumour has all along been extending, and we can study the methods of its growth as well as its relations to the structures in which it has been growing.

Thus it is that, although morbid anatomy by itself may in some cases throw little light on the nature of the disease, yet, taken as an expression of the morbid process, it is of the highest value.

In referring to processes and changes it must be understood that the finer structure of the body is taken into account. In Pathological Anatomy, we include Pathological Histology, and it may indeed be said that, as the coarser, naked-eye appearances are merely the expression of the finer structural details, so we shall not understand the former unless we are able to refer them to the latter. We can have no accurate idea of the proper structure of the normal liver by simply looking at it with the naked eye, and we can have little insight into its morbid conditions by the same method of observation. The morbid conditions, however, do generally cause changes in the naked-eye appearances, and this is of great consequence as enabling us to infer, even from the naked-eye appearances, the character of the change in structure. But these *macroscopic* appearances are only of value when they are used to throw light on the *microscopic* changes or to direct attention to them. The really important processes are those which concern the finer elements of the tissues, and so it is to these that we shall chiefly attend in studying the various forms of disease.

In the investigation of disease by the methods just considered we avail ourselves of the results obtained by labourers in the field of Bacteriology. Bacteriology concerns itself with the study of microbes and has within recent years attained the dignity of a special science, with a special and ever-increasing literature of its own. It will receive consideration here mainly as a development of the ætiological side of Pathology in so far as it tends to throw light on the essential nature of many forms of disease.

Clinical Observation is of great importance in the study of pathology, and that in various ways. It is the processes occurring during life that are the real subject of study in pathology, and it is only by careful clinical observation that we are able to get, as it were, into close relations with these processes during their actual currency. Clinical Observation and Pathological Anatomy should thus be taken as mutually elucidating each other, and as working together towards just conceptions as to the nature of the conditions concerned.

There is another aspect in which clinical observation is of importance in relation to pathology. The pathologist, if conversant only with morbid anatomy and experimental pathology, is apt to form a too mechanical and simple conception of the processes involved, and is likely to theorize on the basis of a too limited view of the subject. Clinical Observation is a needed corrective to this, bringing the pathologist back to the practical aspects of the matter, and checking the tendency to theorize by the discipline of facts.

In the systematic treatment of the various forms of disease, the plan here adopted has been to take up first the diseases in their general aspects, and afterwards the diseases of the special organs and systems. This work, therefore, divides itself naturally into a General Part and a Special Part.

In the General Part will be taken up those diseases which are not confined to any organ or tissue: most of them, indeed, may affect any organ of the body. This is preceded by a Section on the Nature, Causation, and Terminations of Disease.

In the Special Part, the diseases as they manifest themselves in the individual organs and tissues are considered. It is clear that the diseases described in the General Part will again come under review in each division of the Special Part, and they will be taken up very much in the same order as in the General Part. But each disease presents various specialities according to its locality, and, from a practical point of view, it is important to understand the modifications thus brought about. The Special Part will be, in a certain sense, an expansion and amplified illustration of the general principles educed in the General Part.

PART FIRST.—GENERAL DISEASES.

SECTION I.

NATURE, CAUSATION, AND TERMINATIONS OF DISEASE IN GENERAL.

Nature of Disease.—Normal activities of tissues concerned with self-preservation; in disease their efficiency impaired. **Causation of Disease.**—Action of external forces nearly always present, but powers of resistance in the tissues an important element. A. Influence of external forces: I. Direct action of (1) the physical forces, (2) poisons, (3) infective agents; II. Indirect action in producing susceptibility to disease. B. Influence of internal conditions: I. Congenital diseases and susceptibilities; II. Influence of inheritance (1) on racial and individual characters; (2) on anatomical or morphological and physiological abnormalities, (3) on susceptibilities and predispositions to disease, (4) on the constitution of the body as a whole and its individual parts. III. Influence of age and sex. **Terminations of Disease.**—Recovery implies *vis medicatrix naturæ*. Death by failure of respiration or of heart's action.

PATHOLOGY, as we have seen, is concerned with morbid conditions, taking account of the causes of disease, the alterations in the actions, and the changes in the structure of the tissues involved. This implies a knowledge of the condition of the body in health and a comparison between the healthy and morbid states. In this preliminary section it will be proper to lay down some general principles with regard to the difference between normal and pathological actions.

In our conception of the living body we are not to look upon it merely as a whole, but also in its finer elements. John Hunter laid it down as one of his most important primary principles that "every individual particle of animal matter is possessed of life, and the least imaginable part is as much alive as the whole." This principle of John Hunter's may be regarded as the basis of the modern **Cell theory**, which, in the hands of Goodsir, Virchow, and others, has been applied to Pathology. According to this theory, the tissues of the body contain multitudes of quasi-independent bodies, which have their own actions and their own life. We do not properly appreciate any action of the body, whether normal or pathological, unless we take into account the finest details of the tissues and have regard to the active cell-life which goes on there.

The primary actions of the cells will be found to be remarkably similar to those of the larger structures of the body and of the body as a whole. Each of the cells is engaged, in the first instance, in **self-preservation**. It has its own substance to preserve, and it has also in many cases a certain portion of intercellular substance to look after. Its first duty is to resist any disintegrating action and to make up for any waste which may occur in the exercise of its ordinary functions. In like manner the body as a whole has, for its primary action, the preservation of its own existence, opposing its resistance to forces external to itself, and making up for the ordinary waste of life. To this are subservient all the constant organic functions, digestion, respiration, circulation, etc. The individual organs of the body have also, in many cases, special arrangements for self-preservation, which come into play when any interference from without incommodes them in their functions. Thus resistance to forces external to themselves in order to self-preservation enters into the primary actions of all living animal structures. This may be illustrated before going further.

A living egg consists of a single cell, surrounded by a mass of nutritious matter destined to afford material out of which the future animal is to be built up. But the egg, by virtue of the living principle in it, possesses, as John Hunter showed, a remarkable power of resisting external influences. It resists the influence of cold and of the agents of putrefaction to a degree which contrasts very strikingly with an egg which is not alive. When a dead egg (*e.g.*, one that has been killed by previous freezing) is placed in a freezing mixture its temperature soon falls to 32° F., and it begins to swell and congeal. In the case of a fresh egg, however, the temperature falls to 29½° without freezing, and it takes 25 minutes longer than the dead one to freeze. Before freezing, the temperature rises to 32°. Again, all through the process of hatching, the yolk, and what remains of the albumen, continue perfectly sweet; but if a dead egg be in the nest it becomes putrid like an ordinary piece of dead matter under similar circumstances. These observations of John

Hunter show that a small piece of living matter has a special power of resisting the influences of external forces such as dead matter does not possess.

The body as a whole is also engaged in resisting the action of forces external to itself. An example of this is afforded by the preservation of the bodily temperature in warm-blooded animals. In such animals there is a continuous loss of heat by radiation and convection, and it is an important function of the body to compensate for the loss. Again, locomotion and even the retention of the erect posture are effected by the opposition of the various organs of locomotion to the action of gravitation. The resistance to this force involves the functions of bones. ligaments, muscles, and nervous system.

In the actual living body, then, the cells are engaged in preserving themselves from influences which may exist inside the body but are external to themselves,—the regular wear and tear of life,—and the body as a whole is similarly engaged. Health is preserved so long as the individual elements and the tissues as a whole are completely successful in resisting all disturbing influences, so long as they preserve themselves in a perfect state. In that case all the functions are performed with such ease that they do not obtrude themselves on the consciousness, and the body as a whole is preserved from decay and injury. On the other hand, when the forces external to the body as a whole or to its individual elements successfully obtrude themselves and the due efficiency of the living structures is impaired, then we have a state of disease. In disease, therefore, we have to take into account the vital activity of the tissues, chiefly of the cellular elements, and the alterations wrought by forces external to the structures concerned.

CAUSATION OF DISEASE. ÆTIOLOGY.

The actual causation of particular forms of disease is in many cases obscure, because of the limitations of our present knowledge. Looking at disease as a whole and the great groups into which the morbid conditions naturally fall, there are certain general facts as to causation which may be summarily stated.

As disease consists in inefficiency of the elements of the body in performing their normal actions, we have to seek for the causes of this inefficiency in agents or conditions which, directly or indirectly, interfere with the integrity of the living structures. The most obvious manner in which this may come about is by direct interference, by forces external to the body or to its individual elements. The body as a whole is exposed to injuries, wounds, bruises, and it is susceptible to the action of poisons and infections of various sorts. But even in this very elementary statement the suggestion at once occurs that, if we regard different individuals, and, still more, if we regard different parts of the body, the effects of such agents vary greatly. Besides the direct cause of the disease or injury there is, commonly, a pre-existing condition which renders certain structures more liable to interference than others. This pre-existing state, which may be inherent in the actual structure of the part, or may be an acquired peculiarity, may be designated **Susceptibility** or **Predisposition**. An illustration may give reality to these remarks.

Perhaps the most important of the external agents causing disease is a group of microscopic organisms, the bacteria. In the process of self-preservation the elements of the tissue have it as part of their function to resist the intrusion of these microbes or of the poisons produced by them. As microbes are abundant at the mucous and cutaneous surfaces of the body, these surfaces are supplied with continuous layers of cells whose office is to resist the intrusion of the deleterious agents. When the body dies these begin their action on the tissues, and the process of putrefaction leads to the disintegration of the tissue. During life, however, the living epithelial cells restrain their action. There are two ways in which this resistance may be overcome. On the one hand there are certain kinds of microbes which have special ability to overcome the resistance of the tissues, and on the other hand the protecting layer of cells may be removed or breached, and the microbes thus admitted to more susceptible structures, that is, to structures less able to resist. Thus, to give an example of the one form, in an epidemic of cholera the specific microbe, by reason of its inherent powers, obtains a footing in persons previously healthy; and again, on the other hand, wounds or breaches of surface are serious according as they admit the microbes into tissues which are unprepared to resist them. It must be recognized also that, in relation to the same kind of microbe, different persons and different tissues show a remarkable variety in susceptibility. This will be worked out more fully further on, but here attention may be called to it by way of illustration. In an epidemic of cholera, for example, the bulk of the population probably escapes. Thus in the great epidemic in Hamburg in 1892, only about 3 per cent. of the inhabitants were affected, although a much larger proportion must have been exposed to the infection. Again, the microbe of tuberculosis is an exceedingly prevalent one, and it doubtless finds entrance to the bodies of all persons living in communities. But great varieties in the results are manifest. In some persons it obtains no footing, whilst in others it settles in one tissue or another, according to the inherent susceptibility of the person or of the tissue.

The same principles might be illustrated in regard to the ordinary mechanical forces and their influence in the production of morbid conditions. There are injuries which no individual or tissue can resist, but there are lesser injuries which are capable of producing disease, according to the person affected or according to the tissue which has been encountered.

But the causation of disease is not in every case related to the forces external to the body or its individual parts, although the manifestations of disease may be so related. It has been shown above that there are inherent susceptibilities to disease and injury, and it has to be added that there are certain forms of disease whose causation is to be found in an inherent faulty construction or tendency in the living tissue. Varying susceptibility is, as we have seen, related to differences in construction and tendency, but there are also specific morbid conditions whose causation can only be assigned to such inherent, and frequently inborn, faults of structure, growth, or function. A very striking example of this is the disease Hæmophilia, in which, from an inherited peculiarity, the blood-vessels are easily ruptured, so that extensive and even fatal bleeding may occur from a trivial injury. A further example may be afforded by the case of a simple tumour. Thus a piece of adipose tissue, from some inherent perverse tendency, may take to growing and may produce a tumour of huge dimensions.

In considering the causation of disease, then, it will be proper to keep in mind a four-fold division. The **direct cause** may be **external** or **internal**, and, preceding the action of the direct cause there may be a **susceptibility** or **predisposition**, which again may have its origin in **external** circumstances or **internal** construction or tendencies. It is to be noted that such susceptibility or predisposition is to some particular form of disease and not to disease in general. It may exist in a person who is otherwise normal, and it may be present throughout life without the person having been exposed to the direct cause, which is necessary to the production of the disease.

A.—INFLUENCE OF EXTERNAL FORCES IN THE CAUSATION OF DISEASE.

External influences may have a direct or an indirect influence in the causation of disease. That is to say, they may act directly on the tissues so as to bring about certain phenomena which we term diseases, or else they may so influence the tissues as to increase their liability or susceptibility to certain diseases.

I.—DIRECT INFLUENCE OF EXTERNAL FORCES.

1. **The physical forces,** mechanical, chemical, thermal, and electric, often directly affect the tissues. Their effect is to damage the parts on which they act. The mechanical forces cause wounds, bruises, fractures, etc.; the chemical forces produce disintegration or less severe injury to the tissues; excessive heat and cold kill the tissues, and, acting less strongly, do a certain amount of damage. In all these cases the immediate effects are local ones, the living structures acted upon are injured. But as the tissues are living tissues, certain phenomena ensue which are the expression of the physiological processes, altered by the damage done to the tissue. We have a series of phenomena generally grouped under the term **Inflammation,** which arise more or less directly from the damage done to the living structures, and more particularly to the blood-vessels. The phenomena of inflammation are mainly local, having their seat in the damaged part; they are the expression of its own action. To some extent these phenomena are also the result of an attempt in the part to recover from the damage inflicted, or, as it is called, of a **reaction of the living tissues** against the injury done.

But even in the case of purely physical causes, the phenomena do not always remain purely local. As the blood-vessels of the injured part are in communication with the general circulation, the products of the changes occurring in the tissues may be carried throughout the body, and produce changes in the blood and tissues as a whole. An example of this is furnished by some cases of extensive burns of the skin. The blood in the parts exposed to the excessive heat may be damaged; the red corpuscles are sometimes killed. The dead corpuscles are disintegrated and their products are carried with the general circulation, and may do damage, especially while in the process of elimination by the kidneys. Again, in almost all inflammations the fluid of the blood passes out, to some extent, amongst the tissues or on to surfaces. In these situations it may undergo putrefactive or other changes, the products of which may pass back into the blood by way of the lymphatics or veins, and so be carried throughout the body. The result of this is a different series of phenomena, included under the **term Fever or Pyrexia.** Hence fever is a frequent accompaniment **of inflammation,** even when the latter is produced by physical causes.

2. **Poisons**, in the ordinary sense of the word, can scarcely be said to produce diseases. Some of them, indeed, are chemical agents, such as alkalies and acids, which act locally on the tissues, and produce inflammations in the usual way. Others, such as arsenic and cantharides, produce local inflammations, not by any obvious or gross chemical action, but by some more intimate influence on the vitality of the structures. These two agents, like many other poisons, whatever the portal by which they find entrance to the body, being carried by the blood, select certain localities on which to act. Arsenic acts as an irritant on the mucous membrane of the stomach and intestines, producing the phenomena of inflammation there; cantharides acts similarly on the kidneys and bladder. Most other poisons resemble these two in respect that they select a certain locality for their action, and that they produce their effects by some intimate influence on the vital processes of the living tissues, this influence probably having to do with the finer chemical processes concerned in the vital phenomena. In the case of most poisons, the nervous system is more or less affected, many of them having special kinds of actions, and some of them selecting special parts of the nervous system. Thus, strychnia acts as an irritant upon the motor centres of the cord and medulla oblongata. The term **Intoxication** (which literally means poisoning) is used to designate the effects produced on the body generally and more particularly on the nervous system by poisons.

Whilst the phenomena produced by poisons introduced from without can scarcely be regarded as diseases, the same does not apply to poisons produced in the body itself. Most of the disease-producing microbes bring about their effects by means of poisons, and Intoxication is an almost constant effect of diseases so produced. In some cases there is absorption of poisons from the contents of the alimentary canal. in which case the term **Auto-intoxication** is used. Again, the metabolism of the tissues may be associated with the evolution of poisonous products, in which case also the term Auto-intoxication is applicable. The **toxines** so produced, like ordinary poisons, have, in their action, affinities for special localities of the body.

3. **Infective agents** stand in a totally different position from ordinary poisons. The term is used in relation to agents, which, when introduced into the body, increase by self-multiplication, and produce effects altogether disproportionate to their original amount. They may be introduced in exceedingly minute quantities, but they may have very severe effects, resulting even in death.

These agents owe their special characters to the fact that they consist of the living cells of minute microscopic organisms. Most of them belong to a great division of the vegetable kingdom, and are grouped under the general terms **Germs**, **Bacteria**, **Micro-organisms**, and **Microbes**. In a few cases, and especially in malarial fevers, minute animal organisms have been discovered. These minute organisms, whether vegetable or animal, propagate chiefly by simple division of their cells, and do so generally with great rapidity, so that they multiply very greatly in a limited time. They do not usually produce their effects directly, but by means of poisons eliminated by them in the course of their vital processes.

Some of the microbes produce in the first instance purely local effects, these effects having as a rule the characters of inflammations, sometimes with special characters which serve to distinguish the various kinds of agents. Thus syphilis and tuberculosis always begin by the local application of the morbid poison, and their primary phenomena are inflammations more or less modified. But even those which have a primary local seat very readily extend their influence beyond it to the circulating blood, while many forms appear to have no primary local seat, but immediately pass into the blood. It is so with typhus fever, yellow fever, scarlet fever, and others. This extension to the blood may be of the infective agents themselves, the bacteria propagating into the blood and multiplying there, or it may be a mere filtration of the poisonous products of the microbes, the latter remaining local. Thus tuberculosis may remain entirely local, and yet fever is a nearly constant result from the toxine passing into the blood. Indeed there are some forms which apparently never pass beyond their local seats and yet produce general phenomena. Thus the microbe of cholera appears to confine itself to the intestinal canal, but its products are absorbed and produce effects upon the nervous system and otherwise.

The term **Infective Disease** is applied to affections of this class with reference to the fact that the disease is communicated by **infection**, that is to say by the application of such agents as those referred to above. The term **Contagium** or **Contagium vivum** is frequently used in a sense equivalent to infective agent. The mode of extension of this class of diseases amongst the community is somewhat various, and in some cases difficult to determine. There are many in which the disease is simply passed from person to person, either directly or by clothing, excreta, or otherwise. Such diseases are called distinctively **Infectious** or **Contagious**.

But the mode of extension is in many instances not so simple as this. There are some infective agents which appear to reside in special **localities**, being apparently fostered by the special conditions of **temperature, moisture,** and other factors in these localities. In order to acquire such affections a person must visit the locality, and the morbid poison must, as it were, rise from the ground or proceed from its local habitation and pass into his body. The term **Miasma** was applied to such an infective agent, and the diseases were called miasmatic. The most typical instance of a miasmatic disease was malaria.

To the class of disease here under consideration the terms epidemic and endemic are frequently applied. A disease is **epidemic** when it occurs in large numbers within a limited time. The occurrence of an epidemic implies the introduction in considerable quantity of an infective agent, and in such a case the disease will mostly be infectious. On the other hand, a disease is **endemic** when it is habitually prevalent in a particular locality. In that case the disease is most likely to be miasmatic in its origin.

II.—INFLUENCE OF EXTERNAL CIRCUMSTANCES IN PRODUCING SUSCEPTIBILITY TO DISEASE.

External circumstances doubtless produce definite effects on the living body, but these effects are frequently very difficult to determine. Climate, temperature, condition of the atmosphere as regards pressure, moisture or purity, the character of the soil, the dwellings, the food and drink, the clothing, the occupations of men, all have influence on their susceptibility to disease. The geographical distribution of disease and the effects of occupations have been made especially the subject of observations, but a more particular examination of these points scarcely lies within our province.

External circumstances will affect the living tissues chiefly by rendering them less vigorous in their resistance to influences calculated to produce disease. As an illustration of this we may cite the effect of **exposure to cold** in the causation of disease. It is an admitted fact that exposure to cold, especially when the body is fatigued and the general vitality lowered, is frequently followed by attacks of disease. But the exposure can scarcely be the cause of the disease, as it produces in different persons most diverse results. Thus a similar exposure will lead in one person to acute catarrh of the air-passages, in another to acute rheumatism, in a third to acute inflammation of the kidneys, in another to diarrhœa, and so forth. It is clear that the effect of the exposure is, in most cases by reflex nervous influences, to render some part unduly susceptible to the exciting cause of disease, the locality which is thus rendered susceptible being determined often by the individual characteristics of the person. In many cases the disease, indeed, is due to an infective agent, which is able to make good its entrance when the structures are weakened. In what is specifically designated a common cold, the exposure to a low temperature is merely one of the predisposing conditions. Colds frequently arise without any such exposure. The fact that such colds are often obviously infectious is an indication that they are due to infective agents, which latter must be very prevalent in the community.

Occupations will influence the production of disease according as they tend to weaken particular tissues. Employments which imply severe muscular exertion, for instance, cause considerable strain on the vascular system, as every strong muscular effort is accompanied by a closure of the glottis, with suspension of the respiratory movements, and a rise in the blood-pressure. Such efforts frequently repeated will render the heart and large vessels peculiarly susceptible to disease. Hence we find that affections of the heart and arteries, more especially aneurysm, are much more common in men than in women, and in men who are engaged in occupations which require strong and sustained muscular exertion, such as blacksmiths, engineers, sailors, etc. Again, the frequent inspiration of impure air, while it leads to a general weakness of the body, produces a special susceptibility to disease in the lungs. Again, those exposed to extremes of atmospheric pressure are liable to suffer from a peculiar train of symptoms. Divers and men working in caissons employed in bridge building shew the effects of increased atmospheric pressure, while balloonists shew those of decreased pressure.

B.—Influence of Internal Conditions on the Causation of Disease.

From what has gone before it will appear that the condition of the tissues forms frequently a strong predisposing element in the causation of disease. It will also appear, however, that there are certain conditions of the tissues which in themselves are counted diseases, and which arise without any apparent external cause having acted: they are in this sense **spontaneous**, although this expression, as well as the synonymous one **idiopathic**, merely indicates that the cause is obscure.

Looking at the tissues as living, we recognize that in their activity they are capable of morbid change in the direction of defect on the one hand and excess on the other. External causes may produce either of these morbid changes, damaging the tissues on the one hand or stimulating them to undue activity on the other. But the tissues in themselves may be primarily defective or excessive, and may be so either in actual structure or in their tendencies and susceptibilities. It will be proper to consider several different kinds of influence.

I.—CONGENITAL DISEASES AND SUSCEPTIBILITIES.

A condition is congenital when the person is born with it. There are some diseases which are manifestly present at birth, for the causation of which it is necessary to go back to the period of life *in utero*. Some of these are obviously due to the action of external forces, mechanical or other, but there are others in which the causation is quite obscure. Among those whose cause is clear may be cited congenital syphilis, which is always a manifestation of hereditary syphilis. In this case a morbid poison is propagated from the parent to the offspring, and acts on the latter while still unborn.

Many of the congenital diseases consist in **Malformations** of the body as a whole or in part. These occur during the course of development and growth of the body, and consist in errors of excess or defect in the formation or disposition of the tissues. Some of them can, without difficulty, be traced to the action of external forces on the fœtus. For example, a limb or part of one may be amputated in the uterus, and the person may be born with a corresponding defect, perhaps partly remedied by subsequent growth of the injured part. There are probably many congenital defects, which, if they could be traced back to their origin, would be found due to mechanical interference, but it is only in regard to a few of them that this can as yet be done. Such mechanical interference may be due to inflammation, producing adhesion of parts, and thus hindering their due expansion. It seems probable that inflammations play a considerable part in the causation of diseases in the uterus, and these inflammations will be due to the action of external forces just as are those of extra-uterine life.

With regard to **congenital susceptibilities**, these, again, may be divided into those tending towards defect on the one hand and excess on the other. Persons are born, it may be, with certain of their tissues unduly weak and tending to decay. These tissues may give way and become the seat of disease as a result of the action of causes which in most persons would produce no such effect. It may even be that at a certain period of life they may degenerate without any apparent determining cause. Then, as opposed to this, people may be born with a tendency to great excess in the growth of certain parts of their tissues. The causation of **Tumours** or **Morbid growths** is very obscure, but we may say at least that obvious congenital conditions, such as soft warts or moles, are not infrequently the starting points of tumours in later life. We may also infer that conditions equally congenital, but situated so as not to be visible, may be the starting point of other tumours, the susceptibility to which has existed from the beginning of life.

It will appear from what has gone before that congenital diseases are due to a variety of causes, and that they owe comparatively little to inheritance. All that the term means is that the child comes into the world with the disease existent. Congenital susceptibility, on the other hand, will be for the most part due to inheritance.

II.—INFLUENCE OF INHERITANCE IN THE CAUSATION OF DISEASE.

At the outset it is necessary to distinguish two very different classes in relation to the inheritance of disease.

Hereditary Diseases.—The term hereditary disease is usually applied to cases in which a definite morbid condition is transmitted from parent to offspring. The commonest case of the kind is Hereditary Syphilis Here a morbid poison, presumably related to a form of microbe, is transmitted by the parent to the offspring. It is a case in which an external force acting on the parent is directly passed on to the offspring, and becomes active in the latter as it has been in the former. Many of the acute fevers have been similarly transmitted to the child *in utero*, the fœtus either passing through the fever successfully or dying from it. Thus small-pox, intermittent fever, measles, relapsing fever, may be communicated to the child *in utero*. Children have been born with the eruption of small-pox or its cicatrices visible on their skins; others have presented the large spleens and cachectic appearances of ague.

It is obvious that in all these cases the hereditary form of the disease does not differ essentially in its causation from the ordinary forms of the same disease, and that inheritance is in no sense a cause, but merely a mode of transmission of the cause. We may therefore entirely eliminate this class of cases in considering the influence of inheritance in the causation of disease.

Most cases of hereditary disease in this sense are **congenital**, but they are not necessarily so. In the case of syphilis, for instance, the manifestations of the disease may not be present at birth, although later on lesions occur which are due to hereditary transmission.

In regard to nomenclature, it may be well to limit the term **Hereditary Disease** to cases of direct transmission, as in syphilis, and to reserve the term Inherited Susceptibility or inherited disease for cases in which there is no actual propagation of the disease itself.

1. **The General Principles of Inheritance.**—In order to determine the domain of inheritance in the causation of disease, it is necessary first to consider the nature of its influence in the normal anatomical and physiological conditions of our bodies. The facts and theories are, or ought to be, familiar to every student of biology, so that it is unnecessary here to pass these in review. Looking broadly at the subject it may be said that the whole bodily conformation of the animal is dependent on inheritance. It is by inheritance that human beings belong to the Vertebrata, to the Mammalia, and to the genus and species Homo. It is also by inheritance that the more minute peculiarities of races, families, and individuals are produced. This matter is illustrated and elucidated in the observations which follow.

Race the Result of Inheritance.—We see the influence of inheritance not only in the fact that human parents produce human offspring, but also in that the offspring conform to the race of the parents. It is important in connection with what follows to consider what constitute the differences of the races of men. There is more or less pigment in the deeper layers of the epidermis; the hair, in transverse section, is circular or oval in outline, or more or less oval; the nasal bones are articulated at different angles, the lower jaw is more or less massive; the shape and details of the bones of the skull are various; the eyes are horizontal or are directed upwards at their outer extremities; and so on. It is these differences in structure that make the chief distinctions of race, and, if we compare two such dissimilar races as the negro and the Englishman, we shall see that the difference lies in a multitude of details, each of which if taken apart might seem trivial. And yet the fertilized ovum inherits the power of modelling the bodily frame down to these minute details.

Individual Characters the Result of Inheritance.—But, besides the characters which distinguish men as men, and the men of one race from those of another, we know that men are distinguished from each other individually. When we consider the general likeness of the men of one race to each other, it seems marvellous that, among the multitudes with whom we come in contact, we rarely mistake one for another. The only explanation of this is that there are innumerable shades of difference—in colour of skin, hair, and eyes; in shape of nose, mouth, and eyebrows—an infinite number of small peculiarities, which make up the whole portrait. We unconsciously blend the whole of them in our mental picture of the individual, and if one of them be altered we at once recognize that our portrait is out in some way, and has to be readjusted, as when we change the arrangement or length of the hair or beard, or when the mouth is altered by the loss of teeth or the addition of an artificial set. This may be further illustrated by the well-known fact of the insufficiency of photographs. In them we have an exact picture but without the colour, and the absence of this one element in the portrait has often the effect of almost destroying the likeness.

It need hardly be said that most of these fine shades of difference between man and man are due to inheritance. The ovum enters on its career with these already inherent in it, and the various minute points of difference are but repetitions variously compounded of points in its progenitors. We are so accustomed to look for resemblances between children and parents that we are apt to forget what these imply. It is a particular colour of the iris, a special tone in the voice, a trick of manner, such as a twitching of the upper eyelid, or a way of fidgeting with the hand, which recalls the parent or grandparent. These minute points of resemblance become the more remarkable when we remember that they are all inherent in the fertilized ovum. Without any external assistance it goes on modelling the tissues and endowing them with their functions according to a prearranged pattern, and this power continues throughout life; so that it often happens that, on to middle life or old age, points of resemblance come out which had not been previously visible. It is as if the mother and father transmitted to the ovum certain forces inherent in themselves and derived from their ancestors. These forces will be variously proportioned in each case, and the product will be a very complex one. It is quite impossible to tell how, in any particular case, these forces are mingled, but we can often identify the individual items as coming from this or that parent.

A highly important illustration of the truth of what has been adduced is afforded by the facts connected with **Twins**. We have seen that each ovum which leaves the ovary and becomes fertilized is thereby endowed with the forces which mould it into the future human being. These forces seem variously distributed in the ova and the spermatozoa, so that each ovum has them in such varying proportions that even the brothers and sisters of the same family are often very different. But if a single fertilized ovum produces two embryoes, then we might expect that the forces inherent in these two embryoes would be much more nearly alike than usual, and that in consequence the two individuals would resemble each other more closely than is usually the case. And so it is. There are two kinds of twins. In the one the individuals are derived from separate ova, just as are the progeny of animals which bear several young at the same time; while in the other kind, or **homogeneous twins**, there is only one ovum, which probably produces the twins by fission. (See under Teratology.) In the case of twins derived from the same ovum we may look for close resemblance, and they will always be of the same sex. In the other case, where they are derived from separate ova, they may or may not be of the same sex, and they will not necessarily resemble each other more closely than the ordinary brothers and sisters of a family. In a well-known work by Francis Galton we have a collection of interesting facts in illustration of the life-history of twins. He gives many anecdotes supplied by twins as to the mistakes made on account of close likeness, from which it will be gathered that the "Comedy of Errors" is scarcely a burlesque. The resemblance in many cases lasted throughout life, and extended to the smallest matters, even of feeling and thought, and, indeed, to their illnesses. From these facts we have demonstrative proof that in the fertilized ovum we have already inherent virtually all the finer details of structure and function, although many of these only come into effect in after-life. It will be observed that the sex is determined in the ovum.

2. Inheritance of Structural and Physiological Abnormalities.—From what has gone before we have seen that minute differences in local structure are the usual subjects of inheritance. Coming to more considerable differences in structure, such as constitute more or less definite divergences from the normal, it is not surprising to find that they also are inherited.

A common structural peculiarity is **webbing of the fingers or toes**, and this comparatively slight divergence is very distinctly matter of inheritance. The author knows of a case in which the second and third toes of both feet are imperfectly separated, so that, although the bones are complete, the toes are united nearly to their tips by webs of skin. This peculiarity was by a man transmitted to his son, who died in boyhood, to a grandson, the child of one of his daughters, and, although in a diminishing degree, to several great-grandchildren. Sedgwick, in his very elaborate series of papers in the *Medico-Chirurgical Review* for 1861 and 1863, adduces many cases of inheritance of **supernumerary digits**, crooked fingers, cleft iris, squinting, etc. He gives, for instance, a case in which a supernumerary finger was attached to the outer side of the first phalanx of the little finger. The deformity had occurred for five generations, and the person under observation was the fourth child of a family, all of whom except the second were born with this deformity.

There is also the well-established inheritance of **Ichthyosis**, the most striking instance of which is that shown by the family of Lamberts, the so-called "Porcupine family," adduced by Darwin in his "Animals and Plants under Domestication." In the original Lambert the skin was covered by warty projections which were periodically moulted. He had six sons and two grandsons similarly affected, and it is remarkable that the inheritance was confined to the male sex, the two grandsons having seven sisters who were free from the malady. A still more striking instance of the inheritance of ichthyosis is related by Sedgwick. The disease was observed in a boy fourteen years of age, and on tracing his family history it was found that he derived it from his grandfather. This man had been affected with the disease, and it is a striking example of atavism or latency in one generation that none of his children showed the disease, although there were three sons and three daughters, while of seven grandchildren (five males and two females) four of the males were affected and none of the females. The affected males were the children of daughters of the original case.

Hæmophilia or hæmorrhagic diathesis depends on an unknown structural peculiarity either in the blood or vessels, by virtue of which bleeding readily occurs, and when it takes place is stopped with difficulty. This condition is in the highest degree inherited, and it is so in the peculiar manner illustrated by Sedgwick's cases of Ichthyosis mentioned above. Many cases have been traced in their connections, and it appears that it is never directly transmitted. It occurs almost alone in the male sex, and a person affected does not transmit it to his own sons but to those of his daughters. It always in this way misses a generation, and appears in the grandsons of the person transmitting.

Daltonism or **Colour-blindness** is also demonstrably inherited, and it is usually transmitted in the same peculiar fashion as hæmophilia. In nine-tenths of the cases Daltonism occurs in the male sex, and it is usually transmitted to the grandsons of the original case through his daughters. (Sedgwick, Wickham Legg.)

Diabetes insipidus is another condition which is apparently inherited in a remarkable degree. In this affection the person drinks excessively and passes a large excess of urine. We may presumably infer that the kidneys are unduly large, and we know that the bladder is unusually capacious. This was proved in a case recorded by Dr. Finlayson, and was also determined by Weil in the cases to be presently mentioned.

Gee has recorded cases showing that this condition is hereditary, and Weil records a most remarkable instance of its inheritance. Weil met with a case, and he set himself, by hunting up and down the country, to find all about the relatives of his patient, with the result of producing a most elaborate genealogical history of the family. He traced ninety members of the family extending through four generations, seventy of whom were living at the time of the observation. He personally investigated most of these seventy cases. The disease was traced to a man called Johann Peter Schwartz, who was the common ancestor of the family, and was born in the year 1772. His descendants were five children, twenty-nine grandchildren, and fifty-six great-grandchildren, in all ninety-one persons. Of these no less than twenty-three were certainly diabetic, and thirteen doubtfully so. Omitting the doubtful cases altogether, there remain seventy-eight persons, of whom twenty-three were affected, or thirty per cent. According to Weil this condition was perfectly consistent with good health. They were evidently prolific enough and generally long livers. The original Schwartz lived to be eighty-three, and of his three daughters one died at seventy-four, and the other two were still alive at the time of observation, being respectively seventy-six and sixty-seven years of age.

The facts hitherto adduced suffice to show that, in accordance with what we find in regard to normal differences in structure, abnormal peculiarities in structure or function are also subject to inheritance. It now remains to show on a similar basis of fact that susceptibilities to disease are also matters of inheritance, and that the varying susceptibilities of different persons depend on peculiarities, which cannot be, perhaps, demonstrated like those given above, but which frequently coexist at least with definite peculiarities of structure.

3. Inheritance of Susceptibilities or Predispositions to Disease.—We have seen that certain forms of disease are due to the action of infective agents, which, obtaining an entrance into the body, multiply there and give rise to certain phenomena. It is matter of frequent observation that different persons are very variously susceptible to diseases of this class, and it is a notable fact that inheritance plays an important part in determining the varying degrees of susceptibility.

Race is an important factor in determining the susceptibility to this class of diseases.

Amongst the diseases due to pathogenic microbes perhaps the most widespread in the animal kingdom is anthrax, which is produced by the bacillus anthracis. The most marked differences are observable amongst different species of animals to the attacks of this microbe, from immunity in the frog to extreme susceptibility in the mouse and guinea-pig. But a similar difference exists amongst the races of animals belonging to the same species. Thus white rats are extraordinarily insusceptible as compared with common rats. A similar but less extreme difference is noted by Chauveau in the susceptibility of sheep. It is much more difficult to produce anthrax in Algerian sheep than in ordinary breeds, a larger dose being required. The racial peculiarities of this breed determine a striking difference in susceptibility. Pasteur found a similar difference in relation to the poison of chicken cholera amongst the different breeds of fowls. Ordinary fowls are highly susceptible, but those of the Cochin China breed are so to a very minor degree.

In man similar racial differences of susceptibility are observable. In a certain sense the "plague of lice" is a serious disease, and it is highly infectious. According to Murray (quoted by Darwin) the different races of men present great differences in the species of pediculi which infest them, and when the parasites habitual to one race stray on to the bodies of persons of a different one they generally survive only a few days. A structural or physiological peculiarity of the skin connected with the differences of race determines the susceptibility to the attacks of the parasite.

Race has much to do with the susceptibility to **Yellow fever.** There is abundant evidence that negroes are almost entirely insusceptible to this disease, which is so virulent in white men. The immunity of the negro is not due to his having lived for generations in countries where yellow fever prevails, because it is manifest when negroes are brought from parts of Africa where yellow fever is unknown. The absence of susceptibility extends to persons partly of negro descent, generally in proportion to the amount of the negro in their constitution. Negroes seem also to have considerably less susceptibility to **Malarial fevers** than the white races.

On the other hand, **Sleeping sickness** is almost exclusively confined to negroes. Negroes are again more susceptible to **Small-pox** than Europeans, and it generally attacks them in a more virulent form. They are also more susceptible to **Cholera.**

We may infer, therefore, that along with differences of race there go peculiarities of structure and function which determine differences of susceptibility.

Family peculiarities are of the same nature as those of races, the latter being, probably, in their origin derived from the former. There are great and manifest differences among families in susceptibility to infective agents. There are many facts in existence which show that scarlet fever and diphtheria are special scourges in particular families. Again, tuberculosis of the lungs is acknowledged by almost all authorities to prevail in families, so much so that authors use the expression "family phthisis." Further examples of family diseases are furnished by xeroderma pigmentosum or Kaposi's disease and retinitis pigmentosa. It is difficult in the case of families to trace these susceptibilities through a sufficient number of generations, but such facts as those just indicated show that the peculiarities of structure which make family and individual distinctions are correlated to differences in susceptibility to the class of diseases under consideration.

4. **The Constitution of the body the result of Inheritance.**—If we define the Constitution as the inherent structure and powers of the organism, then we shall recognize that the constitution of the individual is made up of an immense number of particulars of structure and function, each of which has been transmitted from a parent or ancestor. These particulars include susceptibilities to disease, so that we speak of **constitutional susceptibility.** As we have seen, each of these constitutional peculiarities is inherent in the fertilized ovum when it enters on its career of development.

It is proper here to notice that **Constitutional Disease** is to be carefully distinguished from constitutional susceptibility. The former implies some serious disorder which has involved the bodily structures and powers as a whole, such as syphilis, gout, and, in some cases, cancer. From this circumstance it is often inferred that there is a contradistinction between constitutional and local, whereas really the constitution is made up of local peculiarities, and constitutional susceptibility is mostly local in its nature.

The term **Diathesis** is sometimes used in a sense nearly equivalent to constitutional disease, but with an implication that there is a constitutional predisposition before the actual occurrence of the disease. Thus a gouty diathesis is supposed to precede as well as to coexist with the actual occurrence of gout. The term, however, is not now much in use, and is not capable of very strict definition.

Besides the constitution of the body as a whole we are able to speak of the **Constitution of the various organs** and tissues of the body, and this is manifested in variations of susceptibility to disease. This may be illustrated by contrasting the susceptibility of the lungs and liver respectively to certain forms of disease. Cancer is a disease characterized by an excessive multiplication of epithelial cells, and it frequently happens that the original tumour sends out offsets, presumably in the form of cells, into structures at a distance, these being in some cases carried by the blood. When implanted in the liver these offsets usually grow luxuriantly, so that there may ultimately be much more cancerous than liver tissue. On the other hand, the same offsets planted in the lungs will grow very little. There is often abundant microscopic evidence of their implantation, but no proper tumours. The lungs and liver are contrasted in an opposite sense in the case of general tuberculosis. In this disease the specific microbe is present in the blood, and is planted throughout the organs and tissues. In the liver it is caught more frequently than probably in any other organ, but it produces only microscopic lesions. These lesions are in immense numbers, but they are rarely visible to the naked eye, and are probably of little consequence to the organ; the microbe is in an uncongenial situation. In the lungs, on the other hand, each implantation leads to a marked lesion of some size, and showing evidences of much disturbance of the tissue. The syphilitic poison presents characteristics different from that of tuberculosis and similar to that of cancer. The liver is frequently affected, the lungs very rarely.

These illustrations might be multiplied in regard to other organs and tissues. That such differences in susceptibility are the result of inheritance is shown by the fact that they are not identical in the different species of animals. Thus, in the guinea-pig and in the ox the microbe of tubercle when implanted in the liver produces obvious and considerable lesions similar to those in the lungs.

III.—INFLUENCE OF AGE AND SEX IN THE CAUSATION OF DISEASE.

It will be understood from what has gone before that age and sex will affect the causation of disease only by increasing or diminishing the susceptibility to certain diseases.

1. **Influence of Age.**—The first weeks and months of life are the most fatal, so much so that about a fourth of the children born die within the first year, while in many towns more than half the deaths are of children under a year old. There are various explanations of this, perhaps the chief being that the helpless infant can scarcely let its wants be known, and being dependent on the care of others, is more susceptible to all sorts of accidental external influences. Hence it is that the children of the well-to-do are much less affected by disease

than those of poorer parents, while illegitimate children who receive least care are much more liable to disease and death than those born in wedlock. Besides this, however, there are other explanations. The child, emerging from the protection and warmth of the uterus, undergoes a sudden transformation in its circulation and nutrition, and at the same time has to cope with physical conditions, chiefly mechanical and thermal, which are new to it. The first days and weeks of life are therefore the most trying to the child. In the child, again, the tissues are growing, and have the double duty of nutrition and growth thrown upon them. They are therefore more liable to derangement than those of adults, although they possess greater powers of restoration when damage is done. The smaller bulk of the child's body, also, renders it more susceptible to changes of temperature, so that cold will penetrate more deeply into its tissues than into those of adults, a fact which is not always remembered in the clothing of children. Besides all this, the bodies of children present, as it were, a virgin soil for the propagation of the various infective agents. The children of the poor can scarcely escape exposure to the ordinary infectious diseases, and their bodies are apparently very susceptible to these influences. A striking illustration of these statements lies in the fact that, in Glasgow, whooping-cough is the cause of more deaths in children than any other communicable disease (Russell). Tuberculosis, also, is extremely prevalent in children, and is much more liable to extend beyond its primary local seat than in adults; as if the tissues of children afforded a better nidus for the infective agent.

The greatest liability to disease is in the first year of life, and it diminishes from the first year to the eighth. From the eighth till the eighteenth year the liability to disease increases, but diminishes after the latter age, reaching a minimum between twenty-four and thirty, to increase from that point onwards. The **mortality** by no means follows the liability to disease. It is, indeed, greatest in the first year, diminishing from that period onwards. The diminution, however, does not cease at the eighth year, but goes on till adult life, the minimum being between the ages of twenty and forty-five. After the latter age the death-rate rises regularly but slowly.

The increase of disease from the eighth to the eighteenth years is related to the fact that these are, in general, the years of school-life and include the time of puberty. School, by exposure in going and coming, and sometimes by too prolonged confinement, not only renders the body less resistant, but also exposes children to infection. The period of puberty, involving serious changes in the bodily functions, is liable to induce a general weakness of the body, and also exposes females to the special affections of menstruation.

In advanced life, the body is liable to diseases which imply decadence or senility of the tissues. The bones are more brittle by reason of a diminution in their animal constituents, and hence are liable to give way under a less severe mechanical strain than are ordinary bones. Senility of the blood-vessels affects their liability to certain forms of disease, and, indeed, the diseases referred to are mainly present in persons past middle life. Affections of the brain are frequent in old persons, but nearly all of these depend on the condition of the blood-vessels, and are not primarily diseases of the brain. Cancer is very specially a disease of middle and advanced life, but not of old age. It is characterized by an excessive growth of the epithelial tissues, and it is difficult to explain how this should occur preponderatingly at an age beyond that of greatest vigour, unless on the assumption that, so long as the surrounding tissues remain vigorous, they restrain any tendency in the epithelial tissues to grow to excess.

2. **Influence of Sex.**—Diseases of the generative organs are of course distinctive in the two sexes. The tissues of the male being, as a rule, larger and firmer, they might be expected to offer more resistance to the external forces, but this is very doubtfully the case, and at nearly all periods of life the female is less susceptible to disease than the male. It is a remarkable fact that apparently in all lands, there are more male than female children born (in the proportion of 103-105 boys to 100 girls). But this disproportion begins to be reduced at the very point of birth, by the fact that more males are still-born than females (in the proportion of 14 : 10). This is apparently due to the fact that male children are on the average more bulky—especially have larger heads, than females, and are therefore more exposed to the accidents of parturition. Even after birth the females show less liability to disease, so that by the end of the first year the sexes are already equal in numbers. Throughout the remaining years of life the females are, at all ages, usually in the majority. Even the dangers of childbearing do not reverse the balance, as the risks are counterbalanced by the greater exposure of men, during the corresponding years of life, to accident and injury in the pursuance of their occupations.

TERMINATIONS OF DISEASE.

The termination of disease is in recovery or death. The recovery may be much prolonged and only partial, or death may ensue only after a long struggle.

1. **Recovery from Disease.**—It has been indicated above that disease is due to an interference from without with the normal physiological processes, or to an abnormal construction or tendency of the living tissues. The existence of such interference or tendency does not abolish the normal functions, but rather, in many cases stimulates them to increased activity. The healthy tissues are continually engaged in dealing with external forces, and are generally successful in so doing; and in cases where the external forces have for the moment obtained the supremacy, the tissues are frequently stimulated to exceptional vigour, so as to overcome the interfering agent. As already indicated, many of the phenomena of disease are really due to the reaction of the tissues against the agent producing the disease. There is therefore on the part of nature an attempt to get rid of the disease, a natural tendency towards recovery. This tendency is expressed in the aphorism **vis medicatrix naturæ**, which implies that the living structures are endowed with a power of overcoming disease.

It will follow from this that recovery is more apt to occur when the disease is due to the direct action of the external forces. In all morbid conditions due to the physical forces, such as wounds, fractures, burns, etc., the tissues at once set to work to repair the injury, and in most cases with considerable success. In the treatment of such diseases the endeavour is made to place the parts under as favourable circumstances as possible for nature to do its part. In the case of diseases due to infective agents, again, we see usually an effort on the part of nature to overcome the morbid agent. According to one theory the elevation of temperature, which is characteristic of fever, is a means of destroying the morbific agent, and at any rate, in most cases, the normal forces after a time reassert themselves and the patient recovers. In some cases, on the other hand, the disease keeps on advancing with very little check on the part of the tissues. It will be found that when this is the case there has generally existed a special susceptibility to the disease, and that the attack of the morbific agent has, as it were, been invited by the special condition of the person. If, after the morbid process has been established, the susceptibility remains, the disease is likely to remain and extend. In tuberculosis this seems peculiarly the case, and it is only by profoundly altering the conditions of life that we are able, as a general rule, to bring about an arrest of the process, without the actual removal of the morbific agent. It may, perhaps, be hoped that in the case of infective diseases, medicinal agents may be discovered which will directly attack the morbific agent, but except in the case of syphilis and malarial fevers, such a discovery has not yet been made.

The tendency to recovery is much less in diseases due to causes in the tissues themselves. Malformations may be partially rectified during the processes of development and growth, but recovery will rarely be complete. Tumours generally continue their growth without reference to the activities of the tissues. The diseases due to decadence of the tissues are seldom the subjects of spontaneous recovery.

2. **Death.**—This is the unfortunate termination of many diseases, but the tendency to death is frequently more an accidental circumstance than a necessary part of the phenomena of the disease.

Life may persist along with the abolition of most of the functions of the body. If the respiration and circulation persist, the remaining functions, even those of the brain, may be in abeyance, and yet the person may survive. If we look at the actual process of dying, we shall find that in most cases the heart or the respiratory movements first give way, although in some instances it may be difficult to determine which has first ceased. According to Bichat there are three modes of death, namely, by the brain, by the lungs, and by the heart, but from what has been noted above it is clear that these may be included in the two mentioned.

Death by the lungs is due to failure in the respiratory movements. This may occur suddenly by paralysis of the respiratory centre in the medulla oblongata, as in hæmorrhages in the brain, but for the most part it occurs gradually from exhaustion of the respiratory centre, and is then called death by **Asphyxia**. Such exhaustion will ensue when, from obstruction of the air passages or vitiation of the air, the respiration has been for a time carried on with great difficulty.

Death by failure of the heart's action is a more frequent mode of death. It may be the result of irritation of the vagus centre in the medulla oblongata from injury to the brain, though in this case the failure of the heart may be simultaneous with cessation of respiration. This form of paralysis of the heart, however, is of rare occurrence. Again, a sudden reflex paralysis of the heart from shock may occur. There may also be death from failure of the heart due to disease in the organ itself, and here also the death is very often sudden. A frequent cause of sudden death, for instance, is obstruction of a branch of the coronary artery. This may lead to such derangement of the nutrition of the heart's muscle as to cause paralysis and cessation of its contractions.

But cessation of the heart's action is often the mode of death when the seat of disease is distant from that organ or its nervous apparatus. In that case the heart is affected secondarily. It is weakened, it may be, by the condition of the blood being altered, so that the requisite amount of nutriment is no longer afforded to the heart; or it may be injured by the blood being increased in temperature or contaminated by abnormal products. In these cases the heart partakes in the general weakening of the body and gradually ceases to contract.

Failure of the heart has an immediate effect on the circulation in the lungs, and we shall see afterwards that œdema of the lungs, which is characterized by exudation of fluid into the lung alveoli, is one of the most constant effects of this condition. The laboured breathing and rattle in the throat, which are so frequent in the last stages of disease, are the usual signs of œdema of the lungs, so that although these signs call attention to the respiratory organs, the real primary failure may be in the heart.

It will be seen that the proclivity to death in the various forms of disease will depend on the degree to which the disease affects the respiration or the heart's action, but more particularly the latter. In this view of it the actual question of death or survival will frequently depend on the staying power of the heart. The ability of the heart to continue its contractions during the most severe period of an illness will frequently determine whether the person is to die or recover. This is an important point to keep in mind in actual practice. There are great differences in the staying power of the heart in different persons, and so there are great differences in the fatality of the same diseases. The ability of the heart, like other local conditions, is largely determined by inheritance. It is probably one of the main factors in determining the duration of life, and longevity depends probably more on the character of the heart than on any other single circumstance.

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SECTION II.

TERATOLOGY.

GENERAL MALFORMATIONS. MONSTROSITIES.

Introduction.—Definition of terms and grouping. Causation of monstrosities. Nomenclature. I. **Monstrosities by excess,** in size or number. A. By excess in size, giants, local hypertrophies. B. By excess in number—Fission of embryo. I. **Complete duplication,** twins, with subsequent partial union (1) of xiphoid, (2) of thorax, (3) of thorax and head, (4) of head, (5) of pelvis, (6) of sacrum. II. **Abcaudal duplication**: (1) head single, and bodies equal; (2) head single, one body undeveloped and parasitic; (3) Duplication of pelvis and legs. III. **Abcranial duplication**: (1) partial duplication of head—double-face; (2) complete division of head—double-head; (3) one division undeveloped and parasitic; (4) supernumerary arms. IV. **Duplication** both abcaudal and abcranial. V. **Triple monsters.** VI. **Reduplication of parts.** II. **Monstrosities by defect** in size or formation. A. Defect in size—Dwarfs. B. Defects in formation arising (1) from dropsy of the cerebro-spinal canal, etc.; (2) from influence of amnion. I. **Extreme Defect in Twin-Fœtation. Acardiaci**: (1) acephalus, (2) acormus, (3) amorphus. II. **Defects involving the head and spinal column**: (1) Brain absent, Anencephalus; (2) brain displaced—Encephalocele, Hernia cerebri; (3) brain defective—Cyclopia, (4) jaw defective—Agnathia; (5) vertebral canal and cord imperfect—Spina bifida. III. **Defective closure of parts in front**: (1) facial clefts; (2) congenital fistula of neck; (3) defective closure of thorax; (4) of abdomen. IV. **Defect of orifices and canals.** V. **Absence or defect of extremities.** III. **Aberrant monstrosities,** chiefly transpositions of viscera.

INTRODUCTION.

THE conditions to be considered here are all referable to errors in the development of the embryo. They are to be traced to causes acting on the embryo and causing it to deviate in its formation either as a whole or in part from the normal. Malformations may consist merely in slight local deviations from the regular type, as where a muscle or a blood-vessel has abnormal relations, in which case the term **Anomaly** is frequently used. On the other hand, they may affect the body as a whole and may be such as to produce the most serious deformities, many of them incompatible with life. In that case the term **Monstrosity** is frequently used.[1] It is with these latter that we are here chiefly concerned. The malformations of individual organs will be referred to in their places, but in this general section we have chiefly to consider those which affect the body as a whole or the more important parts of it. The science of monstrosities or **Teratology** is a very wide one: it will only be possible here to give a general outline of it.

The congenital malformations form only a part of the congenital diseases (see p. 15). In some of the latter we have simply the ordinary pathological changes such as are met with in extra-uterine life, but they have happened to occur in the fœtus. In the case of malformations, on the other hand, the structure of the tissues in themselves is normal, but there is an erroneous arrangement owing to some interference occurring during the period of development.

The malformations are divisible into three great groups. These are malformations by excess, by defect, and by peculiarity of form.

Malformations by excess are divisible according as the size or the number of parts is in excess. There may be an excessive size of the whole body or of some of its parts, but such gigantic formation is uncommon. Much more common is numerical excess, consisting in a doubling or even in a trebling of the body as a whole or of its parts. The group of **double monsters** thus includes a large number of different forms. **Malformations by defect** may be either in the form of abnormal smallness of parts, or of a defect in the completion of the development of certain structures. In the latter case the parts may be of full size, but they represent some period of embryonic life and not that of full development; thus, structures which are formed separately in the embryo in order afterwards to unite and form single structures may fail to do so, and clefts or fissures may be the result. **Malformations by peculiarity of form,** or Aberrant malformations, are local anomalies in which, without any actual defect, the development has taken a different course from the normal, structures which usually atrophy as development proceeds perhaps continuing to grow, while those which usually develop completely are atrophied. Many malformations of the heart and vessels and of the generative organs belong to this class, which also includes many local anomalies. The latter do not fall to be described in this section.

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[1] A monstrosity is "a collection of anomalies which are very complex, very grave, rendering impossible or difficult the performance of certain functions, and producing in the individuals so affected a vicious conformation very different from that which their species usually presents."—Geoffroy Saint-Hilaire, *Traité de Teratologie*, I.

Causation of Malformations.—As the malformations take origin in the embryo at comparatively early stages of its development, it must be generally difficult to trace the exact nature of the cause, but there are at least some indications of the kinds of causative agents.

In the case of the **malformations by excess** we must suppose an excessive stimulation of the embryo at an early period of development, but the nature of the stimulation is difficult to determine. It may here be pointed out, that in certain of the lower animals which are capable of restoring lost parts there is sometimes a reduplication of the parts reproduced. Thus in the case of the lizard, when the tail is broken off, there may be two or three tails instead of one reproduced. In the salamander also, when the foot or hand is amputated or divided longitudinally, there may be a new formation of one or more supernumerary fingers. In these cases the stimulation of the wound, in which the germinal tissue is forming a new member, results in the reduplication of the member. In a similar fashion the over-stimulation of the embryo may induce a reduplication, which will affect the whole body or parts of it, according to the period and locality of its application. The stimulus may in some cases be related to the activity of the ovum and spermatozoa respectively, but there is reason to believe that external stimulation may in some cases have important influences. Thus Gerlach asserts that by varnishing an egg so as to leave only a certain selected part free for the penetration of air he succeeded in certain cases in producing a doubling of the anterior extremity of the chick. Panum, Dareste, and others have also produced malformations by varnishing, by variations of temperature, and by placing the eggs vertically.

In the case of **malformations by defect**, the ordinary principles of causation may be taken into account. The causation is to be looked for in external conditions acting on the fœtus in utero, or in internal conditions inherent or induced in the fœtus itself. In the small and delicate structures which form the early embryo, very slight and simple disturbances may interfere with the completion of parts. Thus, blows on the abdomen may, in their influence, extend through the uterine wall to the fœtus. Further, a potent cause of malformations is constriction or adhesion of parts, chiefly by the amnion. Adhesion is mostly the result of inflammation, and this again may result from injury. Adhesion between the embryo and the amnion at an early period is liable to interfere with the closure of the external structures in the middle line. Such adhesions, being accidental, are apt to produce irregular malformations.

Internal conditions such as accumulations of fluid, or dropsies, are believed to have to do with many forms of defect, more especially those concerning the nervous system. On the other hand, a simple failure of developmental energy has been assigned as a cause of non-completion of the formation of parts.

Inheritance has little influence in the causation of malformations. In the case of the slighter forms or anomalies, such as supernumerary digits, inheritance has a most marked influence, but in the monstrosities proper it has little or no effect.

Sudden frights or shocks are often assigned popularly as the causes of malformations. The sight of a person with harelip or with an amputated limb, by the mother, is supposed to give rise to a like malformation in the fœtus, or even a simple fright is stated as the cause. There is, however, little basis for this opinion, and the assigned cause often happens at a period of pregnancy when the malformation must have been already present. Most of the malformations, as we have seen, are referable to the early periods when perhaps the mother is as yet ignorant of the existence of pregnancy.

Classification.—The chief malformations form a regular series, and subject themselves to a classification on comparatively simple lines. Most of the systems are based on that laid down by Foerster, which has been already indicated above. Cleland has suggested a classification which follows somewhat on Foerster's lines, taking more account, however, of the causation of the lesions. This classification, will be in general followed.

Nomenclature.—It is convenient to designate the various malformations by brief descriptive titles, which shall render them readily distinguishable. The names used for the specific forms will be found to follow a definite plan, and to contain, in Greek derivatives a brief statement of the general features of the malformation.

I.—MONSTROSITIES BY EXCESS.

The excess may be either in size or in number, and these again may affect the body as a whole or individual parts.

A.—Monstrosities by Excess in Size.

1. **General hypertrophy of the body: Giants.**—We include here persons who greatly exceed in height the stature of ordinary men.

As a rule a man who measures 7 feet and upwards is counted a giant; there are cases on record from 7 to 8 feet in height, and even up to 9 feet, although many of the accounts are doubtful. In some cases sexual maturity is delayed or remains absent, and most giants become prematurely old and do not live long.

2. **Local hypertrophies.**—Excessive growth of one half of the body is a rare form of malformation. We have also unilateral hypertrophy of a limb, or of individual fingers or toes (see Fig. 1). The bones of the skull sometimes grow excessively, especially the lower jaw. There are also hypertrophies of the larynx and tongue, and more rarely of the internal organs, which as they have no explanation in any acquired disease, are regarded as malformations.

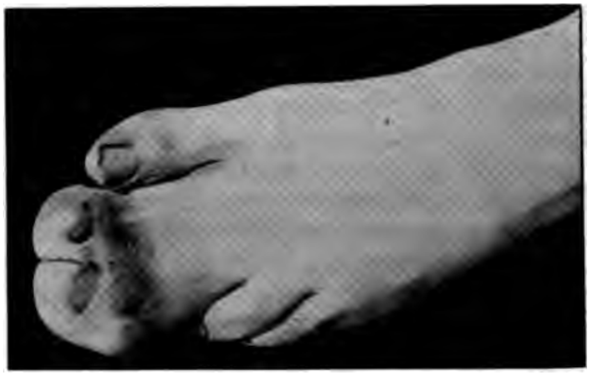

Fig. 1.—Hypertrophy of second and third toes. (W. I. M.)

B.—MONSTROSITIES BY EXCESS IN NUMBER—FISSION OF THE EMBRYO.

These form a very important group, and include a large proportion of the more considerable malformations of the body. They present great variety in form and degree. At the one end of the scale we have the monstrosity consisting of two complete individuals, united by a narrow band, or indeed disunited. At the other end we have simple duplicity or reduplication of parts.

In all cases of double monstrosity there has been, to begin with, one ovum. Opinions have been divided on the question whether in the single ovum there have been originally two embryoes which have partially united, or whether there has been but one embryo which has given rise to the doubled parts by fission. The latter is the more likely explanation in most cases of double monsters.

Multiplication by fission is common in the vegetable kingdom, and is not unknown in the lower forms of animal life. Experiment seems to show that stimulation of the early embryo may lead to doubling in whole or in part. Schultze, for instance, asserts that in the eggs of amphibia, an alteration in the position of the ovum in certain ways, produces a double malformation. We may suppose that stimulations of unknown origin may affect the embryoes of the higher animals. Thus, should there be over-stimulation of the ovum soon after impregnation, there may be fission of the whole germinal mass, with the ultimate production of two separate individuals or twins, which may, however, be partly united. At slightly later periods, when the central part of the cerebro-spinal axis has been already laid down, the fission may still affect the upper or lower end of the embryo, and we may have doubling of these either together or singly, while a portion of the cerebro-spinal axis is single. Then at still later periods when the appendages are being formed, there may be a more local fission leading to multiplication of parts. There are even cases in which the fission has been repeated more than once, so that there is not only a doubling but a trebling of parts, and the monster contains portions of three individuals.

An interesting confirmation of the view that double monstrosity arises by fission of one embryo has been furnished by Cleland in his observations on supernumerary legs. (See further on at p. 39.)

The doubled parts may vary in the degrees of development which they attain. The one may grow much more quickly than the other, and when that is the case the lesser may undergo various degrees of displacement and defective development. As the well-developed division grows in length it may even tear away parts of the less developed one from their relations, and so produce complex arrangements. The more quickly growing part may even come to include the less developed one, and the latter may form a kind of **Parasite** on the former.

Another law has to be remembered in considering double monstrosities, namely, that by which symmetrical parts tend to adhere. This law has a wide application in normal development, lateral parts adhering and coalescing in the middle line. It has also applicability in cases of doubling, the symmetrical parts of one division sometimes adhering to the symmetrical parts of the other. There is, however, not infrequently a partial coalescence and suppression of parts of double monstrosities if they meet in the middle line.

The large majority of double monstrosities are of the female sex, and the two bodies are always similar in sex.

The double monstrosities are divisible into four groups according to the extent and situation of the fission. The division is (1) complete, involving the whole cerebro-spinal axis, or (2) of the hinder extremity —abcaudal fission, or (3) of the anterior extremity—abcranial fission, or (4) of both extremities while a portion of the cerebro-spinal axis is undivided.

I.—COMPLETE DUPLICATION. TWINS.

Most twins are developed from two ova, and are just as distinct as children who are born one at a birth. But the so-called **homogeneous twins** are developed from one ovum, are contained in one chorion, and have a common placenta. They are always of the same sex and closely resemble each other, so closely that their individual identity is often mistaken. In a certain sense such twins are examples of double monstrosities.

There are, on the other hand, twins in whom the cerebro-spinal axis is complete in each, there having been a complete division, but union has taken place and the two are connected by living tissue. For the most part the two bodies are placed parallel to each other, and with the anterior surfaces turned towards each other, and they are usually united by their anterior parts. The explanation of this may be that, as the anterior parts are the last to close, adhesion is more likely to take place here. This rule is, however, not without exceptions.

Although the cerebro-spinal axis is complete, there is in double monsters, not infrequently, a suppression of certain parts, the suppressed parts being symmetrical; as if, being in contact, portions had been crowded out by the growing structures.

1. **Xiphopagus** (*παγείς* = united, from *πήγνυμι*) (*Union confined to the neighbourhood of the umbilicus and xiphoid*).—This is the least degree of union, and is illustrated by the well-known Siamese twins. There is a common umbilicus and umbilical cord, and there is also a cartilaginous bridge between the two xiphoid processes.

2. **Sternopagus** (*Union from umbilicus upwards, to form a single thoracic cavity*).—In this case, as the union is very close, some of the adjacent structures may be united or represented by a single common structure. The two intestines may be united at the jejunum, but double above and below. The liver is usually double, but the two livers are generally united. The lungs are always double, and

the heart usually so, but the two hearts may have coalesced at their borders and be externally single. There is sometimes a partial or complete coalescence of two of the arms, so that there are only three arms. The coalesced arm will arise from the left of the right twin, and the right of the left.

3. **Prosopo-thoracopagus or Syncephalus** (*Union of thorax and head*).—The spinal column and base of the cranium are separate, but the faces have come in contact and partly coalesced There may be two faces, but they are often partially undeveloped (Fig. 2). The union here, as in the two preceding classes, is anterior, so that it is the faces which come in contact and coalesce. Symmetrical parts of the two faces may thus unite, especially those in the middle line, as the mouths and noses, while the ears are brought close together. There is in some cases a peculiar coalescence of the two faces, as if while facing one another they had become flattened out against each other and the parts carried to either side. There are thus two faces, looking to the right and left, but each face really belongs half to one body and half to the other. This form of Mr. Facing-both-ways is called **Janiceps.** Sometimes one of the faces is only a rudiment. In all these forms the mouth and tongue are single in their posterior part; the œsophagus, stomach, and duodenum are single. The lungs, urinary and sexual organs, are double, but the heart single. The arms are nearly always completely double.

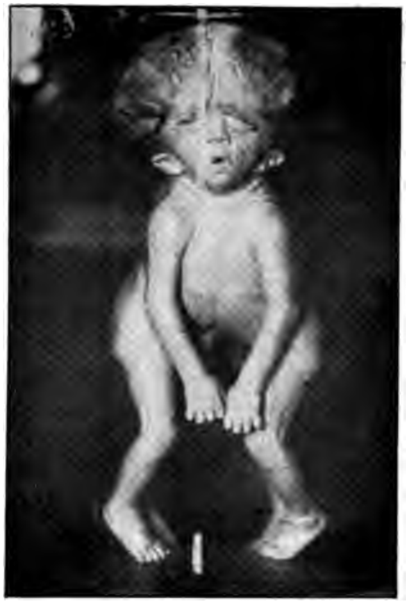

Fig. 2.—Syncephalus. Janiceps.—Twins united by head and thorax. The face shown belongs half to one twin and half to the other. There is another face opposite this one, which is in this case imperfectly formed. (Glasgow Hunterian preparation.)

These three forms are usually included in the genus **Thoracopagus**, and they constitute a very common form of double monster. Amongst them the second or **Sternopagus** is the most frequent. In some cases one of the twins is ill developed, and exists as an appendage to the other, forming a parasite attached to the abdomen or thorax. This form is called **Parasitic thoracopagus**, and is illustrated by the case of Lazarus Colloredo, who was born in 1716, and lived to an adult age. The smaller twin had most of the external parts, with the exception that there was only one leg.

It is customary to include under the thoracopagus parasiticus cases in which the head of the ill-developed fœtus is absent (acephalic parasites), but this is more probably due to incomplete abcaudal fission. (See further on.)

4. **Kraniopagus** (*Union of cranial vaults*).—The twins are complete, and separate except that the cranial vaults have united. The union may be frontal, parietal, or occipital (Kraniopagus frontalis, parietalis, occipitalis).

5. **Ischiopagus** (*Union pelvic, with one umbilicus*).—This is the converse of the preceding form. The two bodies are united below, and diverge from one another so that the heads are at the opposite poles. The two pelves are united, and sometimes the two sacra have coalesced in such a way that the spinal canals are continuous. All the organs of the chest and abdomen are doubled, but one set of the external sexual organs may be imperfectly formed or may have coalesced with the other. There are generally four legs, which are thrown to the sides, but there may be three or only two.

6. **Pygopagus** (*Union in sacral region*).—In this the union is limited to the region of the sacrum and coccyx. There are two individuals who may live many years, as in the case of the Hungarian girls, Judith and Helena, who lived to the age of 22 years. There may be a common sacrum and coccyx, but even these may be more or less divided and the rest of the skeleton is separate in each. The essential distinction from the Ischiopagus is that each individual has a separate umbilicus. The pelvic organs are less united, but there is a common anus.

The **Acardiaci** or **Omphalosites** might be logically included under the group of twin malformations. They consist in ill-formed monstrosities which are born along with well-developed fœtuses. The two are separate but the defective one is connected with the umbilical cord or placenta of the other. It may be more suitable to place these forms amongst the malformations by defect.

II.—ABCAUDAL DUPLICATION.

The duplication in this case may be more or less extensive, from below upwards, and it may involve the whole vertebral column, but the head is always single. One of the halves may develop excessively, and the other may be very imperfect.

1. **Dipygus** (πυγή = buttocks) (*Head single, bodies double and equally developed*).—There is here one head and two bodies, but the bodies and arms may be to a variable extent coalesced. There may be

the regular four arms, or there may be only two; hence dipygus tetrabrachius and dibrachius. This form of double monstrosity is rare in man, but common in animals.

2. **Parasitic forms** (*Head single, one body much larger than the other*).—We have here a great variety of malformations according to the degree of defect of the smaller portion. The fully-developed fœtus is continuous with the head, while the imperfect one seems a mere appendage, or is even broken off from the former. We are able to recognize various modifications.

(*a*) **Acephalic parasites** (*Smaller part appended to front of larger*).—In this form we have the fully-developed fœtus with part of an ill-developed one hanging from the front of the thorax and abdomen in the form of two legs, or two legs with part of a body and two arms. This form is sometimes called **Epigastrius.** It is the commonest form of the parasitic monstrosities, and is illustrated in the case of a Hindu youth, called Lalloo.

(*b*) **Inclusio fœtalis, fœtus in fœtu** (*Smaller part included in the other*).—The included portion is within the abdominal cavity of the larger part (Engastrius), and is very ill developed. It lies in a sac composed of connective tissue, and the parts are rather confusedly mixed, but there are usually recognizable the bones of legs and arms with feet and hands—sometimes also portions of the vertebral column.

Some cases of **Congenital sacral teratoma** are to be included in this group, those namely in which the tumour contains well-defined parts of the fœtus, such as recognizable bones of the skeleton, etc. (See further under Tumours in the class of Teratoma.)

3. **Supernumerary legs** (*Duplication affecting pelvis and appendages*).—There is in this case a duplication which affects the inferior part of the embryo; the primordial pelvis, with its appendages, is duplicated.

From the observations of Cleland, it appears that the two halves present peculiar and interesting relations. The duplication is in the middle line, so that a right and a left pelvis result. As the two pelves are closely connected behind (by the spinal column), there is much more room for expansion in front, and so while the proximate posterior parts are crushed together and liable to imperfect development, the anterior halves attain full development. The result is, two perfect limbs, which, however, belong properly to two different pelves, being the right leg of the right pelvis and the left leg of the left; and in addition, placed posteriorly, a more or less imperfectly formed composite pelvis with supernumerary legs, variously coalesced or dwarfed.

The condition of the supernumerary parts behind varies considerably. There is usually one coalesced limb, like that mentioned above; but there may be two, or the indications of a second.

This subject has been worked out by Cleland in his memoir on "Birds with supernumerary legs," etc. He there refers to cases in the human subject, especially to that of Dos Santos, a monstrosity which has been described by several writers. In this case there was a supernumerary leg attached posteriorly. It had the knee turned backwards, and ended in a composite foot with the great toes joined and the fifth toes at the outer sides. This composite limb, therefore, had not arisen by the fission of two limbs of the same pelvis, but by the coalescence of the left leg of a right pelvis and the right leg of a left pelvis. In front there were two penes between the fully-developed limbs, another indication that the anterior parts and the two developed limbs belonged to different pelves.

III.—ABCRANIAL DUPLICATION.

As in the case of abcaudal duplication the division may be more or less complete, and the lateral halves may be unequally developed, so that in the extreme cases one is parasitic.

1. **Diprosopus** (πρόσωπον = a face), **double-face** (*Partial duplication of head*).—In this there are indications of duplication in the middle line, but the corresponding parts have coalesced more or less, so that while the head is single, the parts of the face are at least partly doubled. In the lowest degree there is apparent externally only a broadening of the head, and there is no doubling of external parts, although the mouth and nasal cavities show a certain amount of duplicity. From this there are successive degrees, the double parts emerging as it were, as successive stages are reached. As the two heads are applied laterally the eyes and nose first emerge, and then the ears. Hence, beginning with the lowest, we have cases with two eyes (*Diprosopus diophthalmus*), with three eyes (*triophthalmus*), with four eyes (*tetrophthalmus*), with three ears (*triotus*), and with four ears (*tetrotus*).

This form of monstrosity is rare, and as the brain and fauces are usually defective, it is not capable of life.

2. **Dicephalus, double-head** (*Complete division of head*).—In this case (Fig. 3) also we have degrees of duplication varying from cases of two heads on one neck to those in which the body is also to a large extent doubled. The condition of the arms indicates approximately the extent of division of the spinal column; hence we have as varieties in different stages, cases with two arms (*Dicephalus dibrachius*), with three arms (*tribachius*), and with four arms (*tetrabrachius*). There are even cases in which an additional lower limb has been present in a

rudimentary state (*Dicephalus tripus*), the duplication having extended almost throughout.

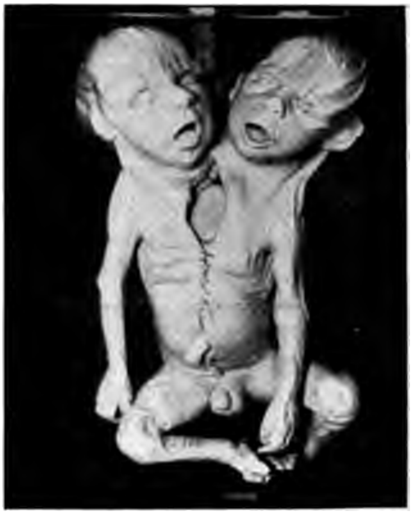

Fig. 3.--Dicephalus. Abcranial fission. (Glasgow Hunterian preparation.)

These forms are very common, forming indeed the most frequent double monsters. The malformation causes great difficulty in parturition, but, if safely delivered, the monster is quite capable of life, and may even attain to old age.

3. **Parasitic forms** (*One division much larger than the other*).—As in the case of abcaudal duplication, so here, one of the halves may develop fully, while the other is dwarfed, and remains as an appendage or parasite.

(*a*) **Epigastrius** (*Smaller part appended in front of larger*).—This form is much rarer than the corresponding one in abcaudal duplication. There is a head and part of the body appended to the thorax and abdomen of a fully developed fœtus, but the parasitic portion is dwarfed. The monstrosity is quite consistent with life.

(*b*) **Inclusio fœtalis.**—To what extent the occasional occurrence of teratoma inside the skull or in the mediastinum may be due to abcranial duplication with imperfect development of one half is not known.

4. **Supernumerary arms.**—As in the case of supernumerary legs in abcaudal duplication, so by a somewhat similar cause we may have supernumerary arms produced in abcranial duplication. In this case the spinal column is single, one of the original divisions having disappeared, but the primordial limbs of both divisions remain. As in the former case also, the outer limbs of each division develop into the proper limbs of the individual, while the internal or adjacent ones become dwarfed appendages. The developed arms are therefore the right arm of the right division and the left arm of the left, while the appended ones are the left of the right and the right of the left. (Cleland.)

IV.—DUPLICATION SIMULTANEOUSLY ABCRANIAL AND ABCAUDAL.

This will present many of the features of complete duplication, but the spinal column will be, in part at least, undivided. There will be two heads or the indication of such a division, and four legs or indications of them. The "Two-headed Nightingale" is a monstrosity of this kind.

V.—TRIPLE MONSTERS.

A true triple monster in which there has been first a duplication of the one extremity, and then a second duplication of one of the parts, is very rare. In one, authentic case there were three heads (**Tricephalus**), two of which were on a single vertebral column, the cervical vertebræ being alone divided, while the other had a separate column to itself. A case of triplication in which two of the fœtuses were parasitic is also recorded. The remains of one fœtus was in the abdominal cavity, and that of the other was appended to the perineal region. (See Foerster, *Missbild.*)

VI.—REDUPLICATION OF PARTS.

The tendency to reduplication does not confine itself to the cerebrospinal axis, but extends to the individual parts of the body, more especially to those accessory parts which, as it were, bud out from the main body.

Polydactylism is the reduplication of the fingers and toes, a somewhat common malformation. The lowest degree is that in which a small appendage is attached by a narrow neck to the outer aspect of the hand or foot. This may or may not have a bony phalanx. In a higher degree the finger has an independent metacarpal bone, and even an added carpal one. In the highest degree the hand or foot has nine or ten fingers or toes. The multiplication may affect one hand or one foot, or both hands or both feet, or all the four members simultaneously. When individual fingers or toes are divided it is most frequently the little one; next to that the thumb or great toe, and very seldom one of the intermediate ones.

These malformations are remarkably subject to hereditary transmission. It is also remarkable that supernumerary digits when amputated are liable to grow again. (See Darwin, "Animals and Plants under Domestication," vol. ii., p. 14.)

Multiplication of bones and muscles.—The coccyx, composed of three or four ill-formed vertebræ, has nine primordial vertebræ in the embryo. A persistence of these would give rise to something like a true **Tail**, but no authentic case has been recorded in man in which bones have been present in the caudal appendage. The vertebræ may be prolonged as a membrane from the coccyx forming a core to a protuberance, but sometimes the appendage is not a proper tail at all, but merely a cutaneous projection.

The ribs are somewhat frequently reduplicated, so that we may have **cervical** or **lumbar ribs**.

Reduplication of muscles is frequent, and some anomalies of this kind are so common as to be regarded as mere varieties.

Supernumerary mammæ are perhaps doubtfully to be regarded as instances of reduplication of parts, as they may be rather due to reversion. There are cases of three, four, and five mammæ. The extra mammæ are usually near the proper ones, and generally under them, but there are cases of very considerable removal, as in the inguinal region, or on the back. The mammæ may be represented only by nipples.

Internal organs are sometimes reduplicated, most commonly the spleen, but also the pancreas and other organs.

II.—MONSTROSITIES BY DEFECT.

It will be understood that we have here to do with the more general defects, and that the distinctly local ones fall under their respective special sections. In studying the malformations by defect we have to go back to the developing embryo, and to see, in interferences with the expansion and development of parts, the causes of the defects.

A.—DEFECT IN SIZE, DWARFING.

Defect in size of the body as a whole results in the production of a dwarf. **Dwarfs** may be well formed although diminutive in size. Generally, however, the head is disproportionately large, and sometimes it is so excessive in comparison with the body as to give the body as a whole a deformed appearance. The body is also sometimes deformed, and the extremities crooked. Dwarfs have frequently good health, and may live to a considerable age. The usual height of dwarfs in the adult state is about 2½ feet, never under 2 feet, and sometimes as much as 3½ or 3¾ feet.

Partial dwarfing occurs in various parts of the body, but especially in the extremities. The extremities may be well formed, but defective in size. This may affect all four limbs, **micromelus**, or the arms, **microbrachius**, or the legs, **micropus**. The head is often small in idiot children, **Microcephalus**, and the brain is correspondingly dwarfed. There may be defect in individual parts of the brain, as the cerebellum. (See under Nervous System.) The face is sometimes at birth dwarfed on one side, **Hemiatrophy**, this apparently depending on some affection of the brain. The intestine may be abnormally short.

B.—Defects in the Formation of Parts.

These lesions consist in the incomplete closure of the arches in front or behind, or in defective formation of the limbs or other parts. It is to be remembered that, in the embryo the original blastoderm gives origin to three layers, the upper and lower of which (ectoderm and endoderm) develop laterally and form arches on either side, which are destined to close in the middle line on the dorsal and ventral aspects. There are thus the dorsal or neural arches, and the ventral or visceral ones, either of which may remain unclosed in the middle line.

Causation.—Although the causation is obscure in many cases, yet the constancy of some of the resulting forms shows that common influences have been at work. Of these influences, dropsy of the cerebro-spinal canal, as a cause originating in the fœtus, and interference by the amnion having an external origin, seem to be the most potent.

1. **Causes in the fœtus itself** are mainly of two kinds, namely, want of energy in the formative powers, and disease in the fœtus, chiefly dropsy, calculated to interfere with the closure in the middle line of the neural or ventral arches. It is difficult to assign their due places to each of these causes. In the case of defect in the cerebro-spinal canal, there are cases of extreme defect of the neural arches, including nerve structures, bones, and integuments such as to suggest a primary defect in the formative power. On the other hand over-distension of the closed neural canal (ultimately represented by the ventricles of the brain and the central canal of the spinal cord) by fluid, constituting a dropsy, is not uncommon, and if it occur early it may interfere with the closure of the enveloping structures, the bones and soft parts. Again, the dropsy may be such as to lead to rupture of the canal, in which case there will be a secondary incompleteness of the neural canal, as well as of the enveloping structures. Opinions differ as to the part taken on the one hand by imperfect formative power, and on the other by dropsy and rupture in the production of these malformations.

In regard to the ventral arches the question of causation in the fœtus itself is also obscure. Dropsy does not seem so frequent here, but rupture of the allantois from dropsy is probably the cause of defects in the closure of the abdomen below the umbilicus.

2. **Influence of the Amnion.**—The amnion may be the agent in producing malformations in two ways, namely, by adhesion to the developing parts, or by pressure on the parts so as to hinder their growth. The amnion is formed by a backward projection of a double layer from the blastoderm close to the embryo. This occurs first at the cephalic end, and then a very little later at the caudal extremity. The projecting folds come together behind so as to enclose the embryo in a sac, in which, however, the anterior (or ventral) aspect is not included. The embryo gradually sinks into this sac as the amniotic fluid accumulates.

The developing amnion is most closely related to the cephalic and caudal ends of the embryo, and any defect or lesion referable to it will affect particularly the head and especially the face, or the pelvis and lower limbs. Adhesion of the amnion to the embryo will necessarily interfere with the active cells in their constructive process.

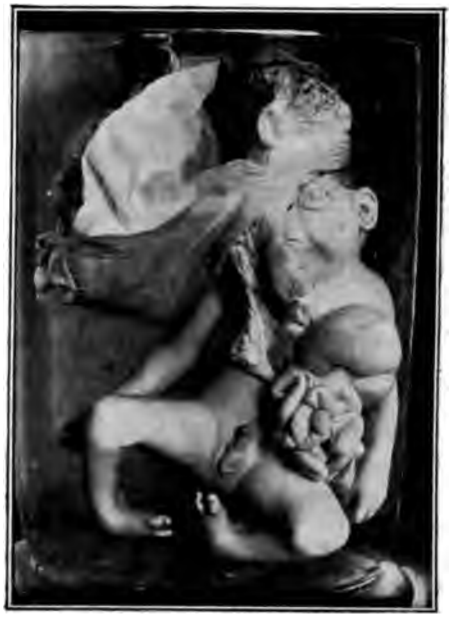
Fig. 4.—Adhesion of Amnion. Protrusion of brain, heart, liver, stomach, and intestine. (W. I. M.)

As the adhesion of the amnion is an accidental circumstance, the resulting lesions are likely to have an irregular character. This is shown in Fig. 4. In this case the amnion is seen to be adherent not only to the head, but to the heart, which is drawn out of the body with its apex upwards. There is great defect in the head and trunk, due to imperfect closure, and there is protrusion of brain, heart, liver, stomach, and the greater part of the intestine. Again, an amnionic adhesion may be drawn out into a cord, and this by constricting parts, such as the neck or limbs, may lead to strangulation, imperfect development, or even to amputation of parts. But, further, the mere non-expansion of the amnion may by its close contact, without adhesion, seriously interfere with the development of parts, and may have the effect of destroying certain of the developing structures. This may explain certain defects of the face, such as cyclopia and agnathia. It also explains the various degrees of deformity of the lower extremities included in the group of siren-malformations.

It is to be remembered that these interferences by the amnion are likely to occur at an early period, when it is in process of formation or shortly after. At these early periods a minute group of cells may represent a considerable portion of the future body, and a slight interference may lead to marked deformity. It will be noted also that the defects will be mostly in the middle line.

I. EXTREME DEFECT IN TWIN FŒTATION. ACARDIACI.

In cases of two embryoes originating from one ovum, which, as already described, gives rise to homogeneous twins, separate or united, one of the embryoes may develop normally whilst the other is faulty. In the case of ordinary homogeneous twins there is only one chorion, and consequently a single placenta, but each fœtus has its own district. It may happen that one of the embryoes, by reason of greater vigour in its cardiac contractions, may largely monopolize the placenta, and so cause atrophy or death of the other, or death may occur from other causes. In either case the defective or dead fœtus is crushed by the vigorous and growing one, and is flattened out and atrophied. At the period of birth there may be only the parchment-like remains of the defective twin, the so-called **Fœtus papyraceus,** which is generally born subsequent to the perfect one.

Again, in a twin-fœtation one of the embryoes may completely monopolize the placenta, this occurring, according to Ahlfeld, by a more vigorous growth of the allantois in the one, so that it takes up the whole chorion to the exclusion of the other. The allantois of the less vigorous embryo may attach itself to the placenta of the other, or even to the umbilical cord, and the fœtus, although completely separate from the other, will depend on it for its blood supply, and will only receive blood which has passed through the body of the more vigorous twin. The result is an exceedingly defective formation, which may be in various degrees. As the circulation is carried on by the more perfect twin, the defective one has no proper heart, hence this group is frequently designated **Acardiacus.** According to Hirst and Piersol, there is sometimes a rudimentary heart. Hence they suggest the name

Omphalosite (ὀμφαλός = umbilicus), as the monster is attached by the umbilical cord to the other.

A different origin for these forms has been suggested by Cleland. He supposes an abcaudal or abcranial fission, and that the smaller part has been broken off from the larger so as to become independent.

Acephalus.—This form presents various degrees of development of the body and limbs. There may be only pelvis and legs, or there may be part of the vertebral column, and even thorax and arms. The legs and arms, if present, are often coalesced. There may even be some trace of cranial bones. The lungs and heart are always absent.

Acormus (*Smaller part completely separated*).—In this form the separated portion consists of a head either with no spinal column or a short piece. The head itself is ill formed, the parts frequently much altered. The umbilical cord proceeds from the neck. There is, of course, no heart, as there is no trunk.

Amorphus.—In this form there is a rounded mass covered with skin, and showing externally no indication of parts of the body. It contains internally fat and connective tissue, with a rudimentary vertebral column. Sometimes there is more of an approach to human form, and the mass contains distinguishable rudimentary parts of the body.

II. DEFECTS INVOLVING THE HEAD AND SPINAL COLUMN.

As already indicated, there are various degrees of this defect. It is important to bear in mind that we may have a more or less complete absence of the bone and cutaneous structures which cover in the nervous system, so that the imperfect remains of the latter are exposed. In this case we speak of the lesion as **open**, and, if the condition is present in the head we use the term **Cranioschisis**, and if it be in the spinal canal, **Rhachischisis**. On the other hand, the cutaneous coverings may be virtually complete, although the bones are usually defective. In this case the lesion is **closed**. There is commonly in these forms a tumour-like protrusion of the nervous structures or their membranes, a condition expressed by such terms as **Encephalocele**, **Syringocele**, etc. Besides these, there are less regular defects, some of which owe their origin to adhesion or constriction of the amnion.

1. **Anencephalus** (*Cranioschisis*).—This name implies that the brain is absent. It arises by a non-closure of the medullary canal or an early rupture of it.

The child is often born at the full time, and the trunk and limbs are usually well-developed. But the vault of the cranium is absent, and the base of the skull exposed (see Fig. 6). The base is occupied by loose membrane in which there may be some cysts. Occasionally there is a vestige of brain, with perhaps a small cavity communicating with the surface, in which case the early defect has been limited and has allowed of some development of the brain. The membrane at the base represents arachnoid and pia mater turned aside, with the ventricles exposed. In some cases there is a sac occupying the place of the brain, and representing the distended but unruptured ventricles. The absence of the cranial vault renders the eyes unduly prominent as they project at the edge of the open skull (see Fig. 5), giving the head the appearance of a toad, from which the malformation is sometimes called popularly *Toad's Head*.

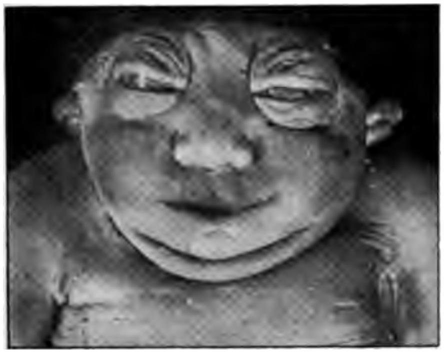

Fig. 5.—Anencephalus. (W. I. M.)

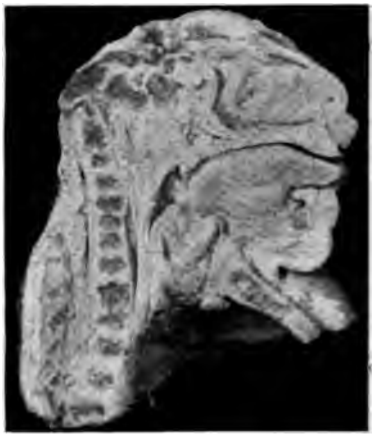

Fig. 6.—Anencephalus in median section. The cleft passing horizontally and downwards from right to left is the mouth and fauces, with tongue below and palate and nares above. The bodies of the vertebræ are surmounted by the bones of the base of the skull seen in section. (W. I. M.)

The cranium shows almost complete absence of the flat bones of the vault, a shortening of the base and an angular curvature between the sphenoid and occipital bones (see Fig. 6). In view of the open state of the cranium anencephalus is sometimes designated **Cranioschisis** or **Acrania**. The malformation is often combined with a similar lesion of the spine (spina bifida).

2. **Encephalocele, Hernia cerebri.**—In this case the brain or a portion of it projects outside the skull (see Figs. 7 and 8). There may be distension of the ventricles in the extruded part (*Hydrencephalocele*) or there may not. It arises by dropsy of the ventricles without rupture.

In the more extreme cases (as in Figs. 7 and 8), the cranial bones are flattened down so as to form a very diminutive cranial cavity, while the brain, sometimes nearly of full size, lies outside, communicating with the interior through an aperture in the bones. In this case there has been at an early period a partial dropsy, which has caused displacement of the brain, and there is often evidence of this in the presence of two or three vesicles in the diminutive cranial cavity. Cleland has shown that these vesicles sometimes represent dropsical olfactory lobes with infundibula, which have pushed backwards the cerebral hemispheres, the latter at the period concerned being of small size. In other cases the extruded brain is hydrocephalic, and sometimes there is little more than a sac containing fluid (sometimes called *Meningocele*).

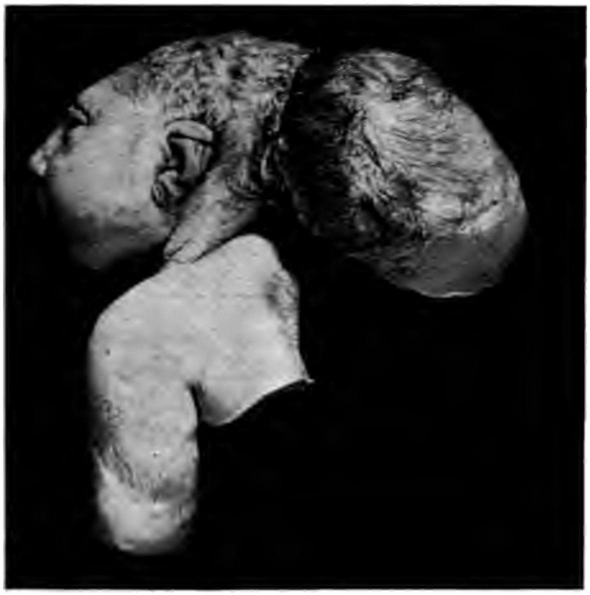

Fig. 7.—Encephalocele. (W. I. M.)

The position of the protrusion is most commonly behind the occiput or at the root of the nose, constituting encephalocele posterior or anterior. In rare cases it is lateral, the protrusion being above, in front of or behind the ear. It is also rarely seen projecting upwards, or downwards into the sphenoidal sinus, the nares or mouth.

3. **Cyclopia** (*Monophthalmia*).—In this condition there is a single orbital cavity in the middle line, containing, in some cases, only a

rudiment of the eyeball (Fig. 9), in others a fully-developed globe, or it may be two, close together. There is no retina in the eyeball, which consists alone of parts developed from without. The cerebrum consists of one mesial portion, containing a single ventricle.

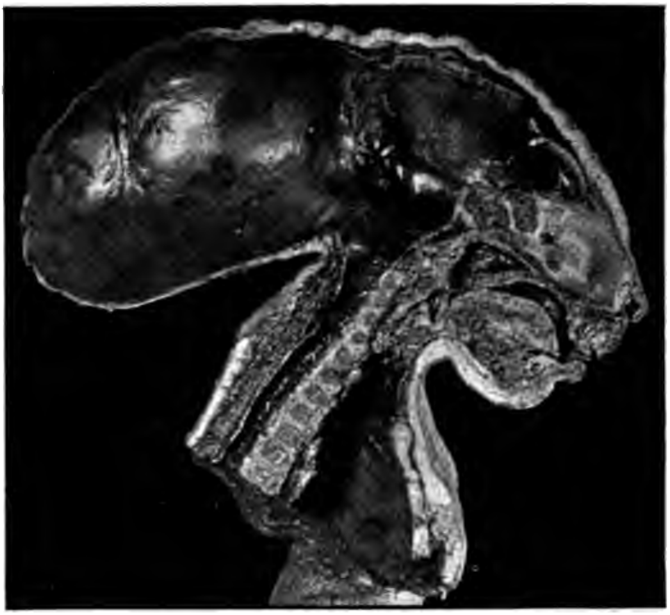

Fig 8.—Encephalocele in median section. The diminutive cranial cavity has a wide communication with the sac, which contained a nearly full-sized brain. (W. I. M.)

According to Cleland there is here a dropsy of the roof of the thalamencephalon, including the pineal body. The enlargement of these parts causes defect of the anterior cerebral vesicle, and by its pressure also interferes with the development of the face.

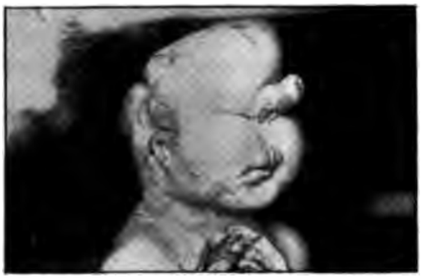

Fig. 9.—Cyclopia. Deformed nose projects above orbit. (Glasgow Hunterian preparation.)

4. **Agnathia.**—This constitutes a still further defect of the face, apparently from a similar cause. In it the lower jaw is deficient and the ears are brought close together so as to touch one another below. This may be associated with Cyclopia, in which case the brain is defective as in that form of lesion, although otherwise the upper part of the face and the brain are unaffected.

5. **Spina bifida.**—In this condition the arches of the vertebræ are usually more or less incomplete, and there is frequently a tumour projecting whose internal cavity communicates with the spinal canal. But this tumour is absent in certain forms, and the condition may be divided into those cases in which the vertebral canal is open without tumour, and those in which there is a tumour. The condition is commonest in the lumbar region and next to that in the cervical, these being the seats of sharp curvatures in the embryo.

(*a*) **Open spina bifida** (*Rhachischisis*).—This form is strictly comparable with anencephalus, with which it is often associated. The medullary canal has never been completed or an early rupture has occurred. Accordingly the integuments have not been carried to the middle line behind, and the arches of the vertebræ are wanting, so that the vertebral canal is exposed, covered only with a membrane. This membrane is continuous laterally with the skin. The exposed canal does not even form a gutter; it is flattened out and shows at most a slight groove, but is frequently convex posteriorly. The surface of the membrane represents the internal surface of the medullary canal, that is to say, the central canal of the spinal cord, and the cord itself, to the extent of the lesion of the spine, is absent or present as a mere trace, like the brain in anencephalus. In a case described by Cleland the membranous surface was continuous with a dilated central canal, thus proving that the former is really the open central canal. Although the cord is absent, the spinal nerves are present, arising from the membrane in an inner and an outer series, representing the anterior and posterior roots.

Rhachischisis is often associated with anencephalus, in which case it affects the upper part of the spine or its whole length, the condition being inconsistent with life. On the other hand, it may affect a limited area usually at the lower part of the column, being produced by a local rupture or defect of the medullary canal. In that case we may have a persistent dilatation of the central canal of the cord, and perhaps a hydrocephalus.

(*b*) **Spina bifida with tumour.**—In this case there is a persistent dropsy with protrusion of a portion of the sac, a condition comparable with hydrencephalocele. The dropsy may be of the central canal of the cord (*syringocele* or *myelocystocele*), or merely of the meninges (*meningocele*), or the cord may be carried outwards with the protrusion (*myelomeningocele*). In the syringocele or syringomyelocele the central canal is expanded so as to form the internal lining of the sac, and the spinal cord may be atrophied or partially preserved. The nerve roots arise in front of the sac. In the meningocele and myelomeningocele the fluid is in the subarachnoid or arachnoid space, usually the latter, and, according to its seat in relation to the circumference of the cord, will be the condition of the cord itself and the nerve roots. The nerves may lie in front of the sac, or may arise within it and course in its walls.

Spina bifida with tumour may occur in any part of the spine, but is most common in the lumbo-sacral region. (See under Affections of the Nervous System.)

III.—DEFECTIVE COALESCENCE OR CLOSURE OF PARTS IN FRONT.

In the completion of the parts in front, the visceral arches grow forward, and, for the most part, coalesce in the middle line in a fashion similar to that of the neural arches on the dorsal surface.

1. **Facial clefts.**—The face and neck (see Fig. 10), are partly formed by the subcranial and branchial arches, which variously unite with each other and with the fronto-nasal process. In all these there are possibilities of non-union, and so we have various forms of clefts. The incomplete closure may arise by abnormal protrusion of the viscera preventing closure in front, the cause of such protrusion being in some cases dropsical accumulations, more especially in the case of the thorax and abdomen; but it may also be due to interference, by adhesion, or otherwise, with the amnion or allantois. The most extreme case is that in which the fronto-nasal and the superior maxillary processes are defective, and the face presents in its middle part a large opening, which to a greater or less extent

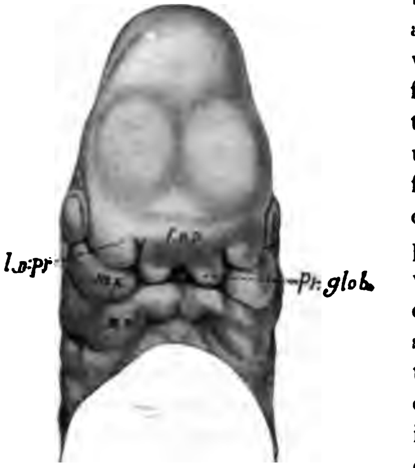

Fig. 10.—Head of embryo. From Quain (after His.) *f. n. p.*, fronto-nasal process. *pr. glob.*, globular extremity of same. *l. n. pr.*, lateral nasal process. *m. x.*, maxillary process. *m. n.*, mandibular arch.

replaces nose and upper jaw, recalling the embryonic condition shown in Fig. 10, and in some cases also involves orbits and lower jaw. This condition is called **Aprosopus** or **Schisto-prosopus.**

Less degrees of it are shown in **Cleft palate** and **Harelip.** The fronto-nasal process forms the central part of the upper lip and of the alveolar process of the upper jaw. Hence, in these parts, the line of union is on either side of the middle line, while in the palate it is mesial. The cleft in the lip and alveolar process is therefore lateral and that in the palate mesial. All degrees of non-union exist, from complete fissure of the palate, with cleft of the alveolus and lip on each side, to the slightest notch on one side of the upper lip. These defects date back to the third month of fœtal life, at which period the closure ought to occur.

2. **Congenital fistula in the neck** (*Fistula colli congenita*).—This arises by imperfect closure of the lateral aspects of the branchial arches. There is a small aperture, only sufficient to admit a small probe or bristle, usually situated half an inch to an inch above the sterno-clavicular articulation, more rarely further upwards and outwards, or in the middle line. The aperture leads into a canal which is directed towards the pharynx or œsophagus, and may communicate with one or other of these. It is stated that the fistula may communicate with the larynx, but this is doubtful (Karewski). The fistula is lined with mucous membrane, and mucus may be discharged at the orifice. There is usually one fistula which is most frequently on the right side or in the middle, but occasionally there are two symmetrically placed.

Occasionally, from a similar origin, we have **Cysts in the neck** without external aperture. These may be filled with serous fluid (*Congenital hydrocele of the neck*), or may have a more epidermic structure and contents, so as to constitute **Dermoid cysts.** By the bursting of these latter, or after opening by the surgeon, a fistula may remain, this being one of the ways in which the fistula colli congenita may originate.

3. **Defective closure of thorax** (*Fissura sterni*).—There are various degrees of this, and various combinations with defect of the anterior abdominal wall, the highest degree being a complete cleft of thorax and abdomen. In these extensive clefts the organs are generally extruded, but even when there is a limited cleft of the sternum, the heart is liable to lie outside the chest. In this **ectopia cordis** the heart generally lies in the middle line, communicating with the inside of the chest by a narrow peduncle composed of the great vessels. The heart itself is usually malformed. Sometimes the heart

lies at the root of the neck, the manubrium being cleft. Sometimes ectopia cordis occurs without any cleft in the sternum, in which case the heart lies in the neck or in the epigastrium, in the latter case projecting through an aperture in the diaphragm. These facts indicate a displacement by pressure from behind, and probably the whole phenomena are due to dropsy of the pleural cavity at an early period.

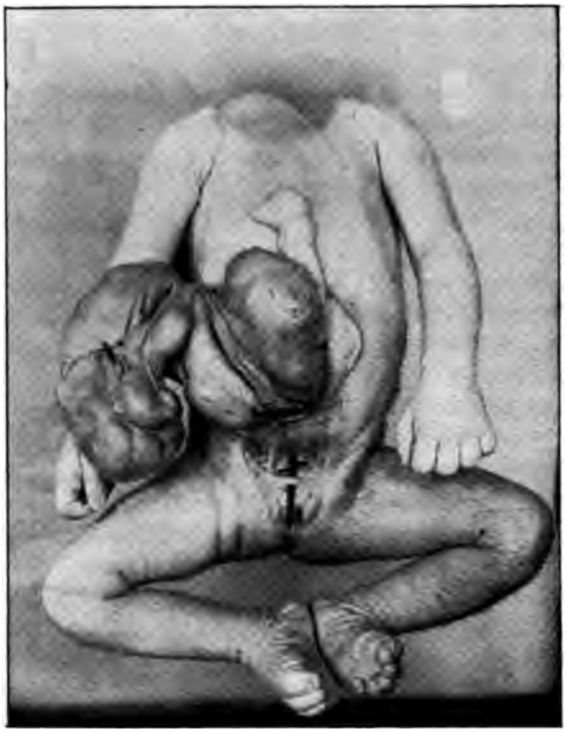

Fig. 11.—Fissura abdominalis. There is a sac containing protruded viscera, namely, intestine and part of liver. Below, the conditions are those of *fissure of bladder*. The long black rod is passed under a bridge which crosses the urethra. To the right of this rod below is a short rod, which passes into vagina; on either side are labia pudendi separated. Above, the small rods on each side are in the ureters.

4. **Defective closure of abdomen** (*Fissura abdominalis*). It is to be remembered that in the early fœtus the anterior wall has a great gap to give transit to the umbilical vesicle and the allantois, and that it is by the gradual contraction of these structures that closure is rendered possible. As noted above, defective closure of the abdomen is sometimes associated with defect of the thorax. In complete fissure of thorax and abdomen, as there is no umbilicus,

there is usually no proper umbilical cord, and the vessels pass directly from the placenta by the amnion to the cleft in the abdomen. The proper abdominal fissure, in its highest degree, extends from the ensiform cartilage to the pubes. In that case the viscera are extruded, the urinary bladder is cleft, and the genital organs are absent or defective. Sometimes the defect is less, and the abdominal contents lie outside the abdomen in a large hernial sac (see Fig. 11). The umbilical cord is usually absent, and the placenta is directly in contact with the sac, the vessels traversing the latter to reach the abdomen. Two special forms merit more particular attention.

(*a*) **Hernia of the umbilical cord** (*Hernia funiculi umbilicalis*).—This is really a minor degree of the condition last mentioned. There is, at the seat of the umbilicus, a rounded tumour, from the distal extremity of which the cord passes off, there being no proper umbilicus. The tumour consists of a peritoneal pouch which is protruded through the abdominal wall. There is an aperture in the wall of the abdomen, and the peritoneal pouch is covered with amnion, which is continuous on the one hand with the surface of the abdomen, and, on the other, with the surface of the umbilical cord. The hernia is one, therefore, of the umbilical cord, and not simply of the umbilicus. When the cord drops off, the amnion goes with it and the peritoneal sac is exposed. If the tumour be large it will become gangrenous, and the patient will rapidly succumb. Even if the tumour be small the exposure generally results in fatal peritonitis, and it is only exceptionally that the gap in the abdomen is closed by healing.

(*b*) **Fissure of the bladder** (*Inversio s. extroversio vesicæ*).—In this condition the abdominal wall between umbilicus and pubes is incomplete. The allantois has failed to close completely inside the abdomen so as to form the urinary bladder, and the lateral borders of the latter are adherent to the sides of the cleft, while the anterior wall is entirely absent. The posterior wall of the bladder therefore fills the cleft, and as it is pushed forward by the abdominal viscera it protrudes as a soft red area of mucous membrane, which readily bleeds, and on the surface of which the ureters open. At the upper end of the cleft is the umbilicus, which is frequently displaced downwards. The conditions shown in Fig. 11 are those of extroversio vesicæ such as occur without the more complete fission shown in that illustration.

The defect generally extends to the parts below. The pubic bones do not meet in the middle line, the rami ending in rounded lateral prominences. In the female the urethra is usually absent as well as the clitoris, and sometimes the vagina is defective or absent. In the male there is a rudimentary penis, which is not traversed by a urethra, but presents on its upper surface a deep groove which represents the cleft urethra.

(*c*) **Minor degrees of incomplete closure in front.**—The cleft may confine itself to the upper part of the bladder, which presents itself as a red protrusion just beneath the umbilicus, the parts below being perfect. A still less degree is a simple **persistence of the urachus,** which then forms an open communication between the bladder and the surface at the umbilicus. We may also have a **Cyst of the urachus** from expansion of a partially obliterated urachus.

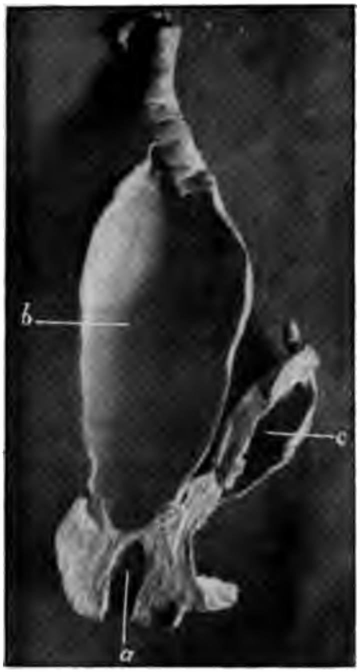

Fig. 12.—Imperforate anus. *a*, Anus and anal part of rectum. *b*, Dilated rectum separated from anal part by a complete septum. *c*, Urinary bladder.

On the other hand it may be the lower part which is defective, the urinary bladder being well formed, but the urethra cleft and otherwise imperfect. In the male this constitutes **Epispadias.** The penis is short and cleft on its dorsum, the urethra forming here a deep groove. The groove ends posteriorly in an aperture which communicates with the bladder beneath the pubes.

The causation of these malformations is obscure. It may be that there is a simple failure in the formative material of these parts, or that an over-distension of the allantois has prevented a proper closure.

IV.—ABNORMAL CLOSURE OR DEFECT OF ORIFICES AND CANALS.

Some of these are local and fall under their special sections, but there is one form which has more general results.

Imperforate anus with persistence of cloaca.—Up to the fifth week of embryonic life there are no external openings for the intestine and urino-genital organs. The rectum is still closed below, but communicates with the allantois, which forms a common opening for the intestinal, urinary, and genital passages, and is itself still open through the imperfect abdominal wall in front. This condition may persist in a greater or less degree.

The most extreme form is where, along with imperforate anus, there is fissure of the abdomen and bladder, a combination of the conditions described in last section with that now under consideration. In some cases the colon is deficient, and the ileum may communicate with the extroverted bladder. Such conditions are hardly compatible with life.

In the simpler forms there is imperforate anus and the intestine communicates with urinary or genital passages. The communication may be with the vagina (*anus vaginalis*), or with the urethra (*anus urethralis*), or with the urinary bladder (*anus vesicalis*). The communications may be very small, so that continuance of life is impossible from accumulation of fæces, but there may be fuller communication, and sometimes the condition is surgically remediable.

Simple imperforate anus may be a simple absence of the aperture, but in many cases there is also a defect of a portion of the rectum. The latter condition may exist while the anus is perfectly formed (Fig. 12). (See further on under Intestine.)

V.—ABSENCE OR DEFECT OF THE EXTREMITIES.

Defective formation of the extremities may be due to a failure in the inherent powers of the germinal matter which forms these parts, or to mechanical interference. Where there is a symmetrical defect, then we may presume that there has been a failure in the material destined for the limbs, whereas a non-symmetrical deformity is probably due to a local interference. As the limbs form by lateral expansion, they are more likely than other parts to come in contact with the amnion and the umbilical cord, or with any band or bridge which may have accidentally formed. There may even be an amputation of a limb by the cord or a band. Various forms are described.

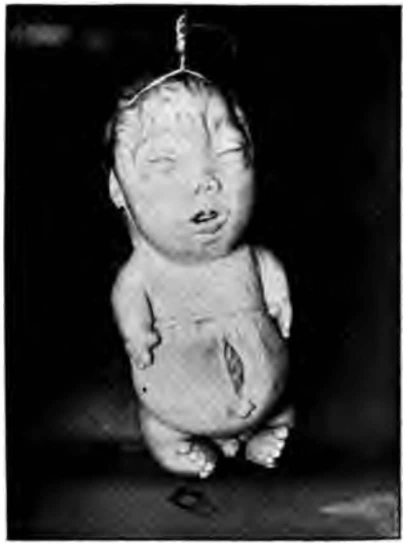

Fig. 13.—Peromelus. The four extremities defective. (Glasgow Hunterian preparation.)

1. **Defect of all the four limbs.**—(*a*) *Amelus* (μέλος = a limb), or absence of all the extremities. The body is usually well formed, but

at the shoulders and hips there are short rounded or warty projections, at the ends of which there may be horny or nail-like appendages. Sometimes there are ill-formed bones present.

(*b*) *Peromelus* (πηρός = maimed). The whole four extremities are defective or deformed (Fig. 13). The body may be well formed, but sometimes the deformity is associated with other malformations which prevent the persistence of life.

(*c*) *Phocomelus* (φώκη = a seal). This is a variety of the former, in which the long bones are absent or very defective, and the hands and feet are seated immediately on the shoulders and hips and are well formed.

2. **Defect of the arms.**—(*a*) *Abrachius.* The upper extremities absent, while the lower are developed.

(*b*) *Perobrachius.* Both arms are defective. The long bones may fail and the hands be planted on the shoulders, or the arms may be short and deformed, and the hands have only two or three fingers. In most cases, however, the upper arm is little deformed, but the fore-arm and hand are defective.

(*c*) *Monobrachius.* Absence of one arm. This sometimes occurs as part of a greater defect of the thorax and abdomen, but the body may be fully developed.

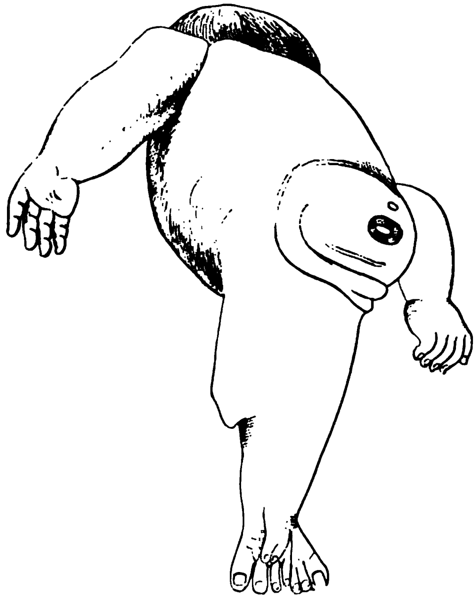

Fig. 14.—Sympus monopus or Siren-malformation.

3. **Defects of the legs.**—Defects of the lower extremity are similarly classified to those of the upper, and have similar characters. We have *Apus*, *Peropus*, *Monopus*. In the last mentioned the absence of the leg may be associated with defect of the pelvis and protrusion of the abdominal contents. In addition to this we have the following special form.

Siren-malformation (*Sympus*: *Symelia*).—In this form the lower extremities are coalesced, and the body is prolonged into a tapering single limb, so that there is some resemblance to the legendary siren with a fish's tail (see Fig. 14). The defect arises at an early period of development, and there is, besides the deformity of the legs, defect of the pelvis and of the intestinal and urino-genital organs. It is probable that in this case, as suggested by Dareste, the amnion by undue impingement on the caudal extremity of the embryo interferes with the growing structures. The interference is in the middle line and occurs at the time when the limb-girdle, which is to form the pelvis, is first formed, which is about the fourth week. The result of the interference is shown in the pelvic bones. The ischial and pubic bones are defective below (see Fig. 15), and their proximal parts coalesced, so that the two ischia form a transverse bar across the pelvis, and the two pubic bones project forward. By this coalescence the acetabula are approximated behind, and may coalesce into one. From the fact of the acetabula being approximated behind, the femora are brought together by their outer aspects, and coalesce by these (see Fig. 16), which are fixed in the middle line. This explains the peculiar position of the coalesced limb, which has the knee with the patellæ looking backwards and flexed forwards, and has the foot with the plantar surface facing forwards and the great toe outwards (see Fig. 14).

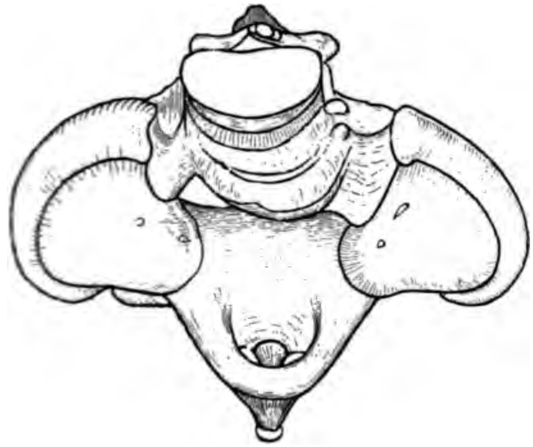

Fig. 15.—Sympus. Pelvis seen from the front. The ischial bones coalesced across the floor. The pubic bones coalesced and projected forwards.

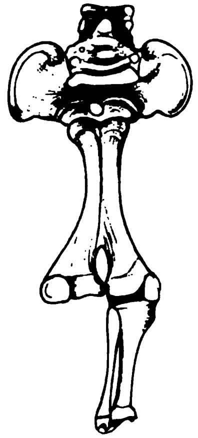

Fig. 16.—Sympus. Bones of pelvis and leg, from behind. Femur, with two heads and two lower extremities. Glenoid cavities close together behind.

Various degrees of the deformity are met with according to the degree of coalescence of the limbs and of suppression of the parts which meet in the middle line. The foot may be absent (*Sympus* *apus*), or there may be one foot at the extremity of the combined leg (*Sympus monopus*). The single foot is variously supplied with toes—the two outer are always the great toes, and the number of others is various—or there may be two distinct feet with the full complement of toes (*Sympus dipus*). In this last form the other constituents of the limb will also be less united, and there may be two femurs, but the soft parts are coalesced.

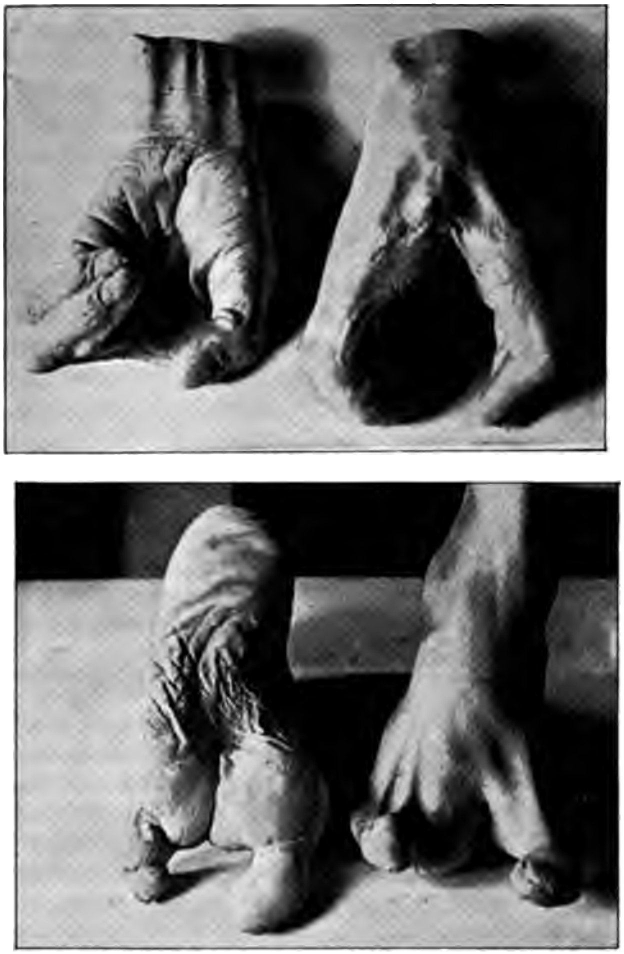

Fig. 17. Congenital deformities of fingers and toes occurring in the same person.

In the siren there is always defect of the external organs of generation, which are often absent altogether. The anus is usually absent, although not so in the case figured above. There are also sometimes defects in the intestine in its course.

4. **Defects of the fingers and toes.**—These present themselves as *absence* or *defect of the digits*, and as *coalescence*. These are very frequent malformations, and they may affect all four members, as in Fig. 17, or be limited to two or one. In cases of coalescence it is usually only the skin which unites the fingers or toes, but sometimes the muscles and tendons are united, and more rarely the bones.

These defects of the fingers and toes are, like polydactylism, in a high degree inherited. This applies to the symmetrical forms, and not to such defects as may be due to mechanical interference, as by amputation.

III.—ABERRANT MONSTROSITIES.

In this division we include malformations in which there is little or no quantitative defect, but there is a qualitative difference from the normal, an error in the development; they are the forms which Foerster has classified as *Monstra per fabricam alienam*. The malformations affect the thoracic and abdominal viscera and the external organs which are in immediate connection with them. The heart and blood-vessels and the generative organs are most frequently affected. The malformations of these will be described in their special section; we have here to deal with general monstrosities.

Transposition of the viscera (*Situs transversus*).- This malformation is not very rare. The entire viscera of chest and abdomen are transposed, so that the aorta comes off from a right ventricle, the venæ cavæ are on the left side, the liver is on the left, the spleen on the right, and so on. The organs are properly formed, and their function is normal. The existence of the malformation may altogether escape observation, or may be accidentally discovered when the person is being examined medically.

Transposition is constant in double monsters, the left twin having the normal arrangement, and the right having the viscera transposed. This seems to indicate that in single embryoes the usual situation in the umbilical vesicle is left, but that occasionally it may be right, in which case the viscera are transposed.

Literature.—Meckel, Handb. d. path. Anat., 1812-1818; and De duplicate monstrosa comment., 1813; Etienne Geoffroy St. Hilaire, Philosophie anatomique, vol. ii., 1822; Isidore Geoffroy St. Hilaire, Traité de tératologie, 1832-1837; Vrolik, Tabulæ, 1849. The fullest account in Foerster, Die Missbildungen des

Menschen, with atlas, 1861, and in AHLFELD, Die Missbildungen des Menschen, 1880-1882, also with atlas; in both of these the literature very fully; also GERLACH, Die Entstehungsweise der Doppelmissbildungen, 1882: PANUM, Die Entstehung der Missbildungen, 1860; DARESTE, Recherches sur la production artificielle des monstrosités, 2nd ed., 1891; HIRST and PIERSOL, Human monstrosities (causation, classification, and literature somewhat fully), 1892; RAUBER, various papers on the theory of monstrosity by excess, in Virchow's Arch. vols. lxxi., lxxii., lxxiii., lxxiv. CLELAND, Journal of Anat. and Phys., vols. viii., xii., xiii., xvii. Trans. of Philosoph. Soc. of Glasgow, 1885-86. Address on Rational Teratology, Brit. Med. Jour., 1888, vol. ii., p. 346, also Memoirs and Memoranda in Anatomy by CLELAND, MACKAY, and YOUNG, 1888. HIMLY, Fœtus in fœtu, 1831; SNEDDON (*Supernumerary mammæ*), Glasg. Med. Jour., pp. 69 and 120, 1878. BANNATYNE, Diseases and Deformities of fœtus 1894-95, Teratologia, a journal, vol. i., 1894, Antenatal Pathology and Hygiene, 1902. TEACHER and COATS *Siren*), Jour. of Path., 1895.

SECTION III.

AFFECTIONS OF THE CIRCULATION AND DISTRIBUTION OF THE BLOOD.

Physiology of the Circulation.—Innervation of Arteries, etc. **Local Hyperæmia.**—I. Active hyperæmia; caused chiefly by dilatation of arteries; phenomena. II. Passive hyperæmia; caused chiefly by weakness of heart or venous obstruction. Phenomena, including diapedesis, œdema, etc. **Local Anæmia** or **Ischæmia**; chiefly from obstruction of arteries. **Thrombosis.** Coagulation of the blood. The process of thrombosis shown by experiment; characters and forms of thrombi. Causation, from stagnation of blood; from alteration of wall. Growth of thrombi. (Absence of thrombosis from capillaries.) Changes in thrombi, chiefly softening and organization. Results of thrombosis. **Embolism.** Causation, chiefly by thrombosis. Phenomena, in (1) Arteries with free anastomosis; (2) Arteries with imperfect anastomosis (End arteries); in them, (*a*) Engorgement of vessels, (*b*) Hæmorrhage, and (*c*) Necrosis; disposal of infarction. Special forms of embolism, malignant tumours, fat, air, and infective. **Hæmorrhage**; by rupture or by diapedesis; causation various; stilling of hæmorrhage; seats of effusion and disposal of the blood. **Œdema and Dropsy,** depend on the lymphatic circulation. Causation and nature of process; rarely from lymphatic obstruction; usually from passive hyperæmia; hydræmia and hydræmic plethora as causes, especially in Bright's disease; nervous influences in causation. Position and character of exudation.

Physiology of the Circulation.—In the distribution of the blood the capillaries and veins may be regarded as virtually passive channels. They are able to accommodate more or less blood according to circumstances, but of themselves they have little to do with the variations in the supply. The supply of blood to the tissues varies, chiefly according to their needs; the brain or muscle while working requires and gets a fuller and more rapid supply of blood than when at rest. This supply is regulated by the arteries; when they dilate more blood passes into the capillaries and on to the veins, and when they contract less blood reaches the capillaries and veins. We may regard the arteries as regulating the supply of blood, the capillaries as distributing the blood, bringing it within reach of the elements of the tissues, and the veins and lymphatics as carrying it off. The amount of blood admitted by the arteries depends on the state of contraction or relaxation of the muscular fibre-cells in the middle coat, and this, like all other muscular actions, is under the command of the nervous system. When the vaso-motor nerves are stimulated the muscular coat contracts, when these nerves are paralyzed it relaxes, and when a moderate amount of stimulus is supplied, then we have that state of moderate contraction to which the name of tonicity is applied.

Innervation of arteries.—Constriction of vessels is brought about by stimulation of a special set of nerve-fibres, the *vaso-constrictors.* These have been shown to run in the sympathetic nerves, and also in the cerebro-spinal nerves of the extremities, where they are perhaps derived from the sympathetic system. Division of constrictor nerve-fibres will induce relaxation of arteries, because it will remove the stimulation which keeps up their tonicity.

Bernard's discovery of the fact that electric stimulation of the chorda tympani causes dilatation of the vessels of the submaxillary gland proved the existence of *vaso-dilator* fibres, and further observation seems to prove that both kinds of fibres pass to the vessels in all parts of the body. Both kinds probably belong to the sympathetic system.

These facts have suggested that the regulation of the calibre of arteries is effected by the nerves through the intermediate action of local nervous ganglia in or near the walls of the arteries. Arteries may be compared in their innervation as well as in their structure to the heart. The heart has intrinsic ganglia and it has accelerator fibres derived from the sympathetic which stimulate these ganglia, and inhibitory fibres from the vagus which depress them. Nervous ganglia have been discovered in the neighbourhood of a few arteries, chiefly those of the submaxillary gland and the penis. The arteries generally are surrounded by a close plexus of nerves, and the facts of the case can only be explained on the assumption of local centres. A further proof of this is to be found in the fact that when arteries are cut off from all central connections they are still capable of varying their calibre. If the sciatic nerve in a frog is divided, the arteries indeed dilate, but after a time they resume, at least partially, their state of tonicity, and are capable of still further variations. Again, an excess of carbonic acid in the blood will cause arteries to contract after all their central connections have been severed, and they may be made to dilate by means of chloral or amyl nitrite.

The vaso-motor nerves are known to run, to a large extent at least, in the sympathetic system, and they are under the influence of the sympathetic ganglia. The sympathetic system, however, is not an independent one, and the proper vaso-motor centres are in the spinal cord and medulla oblongata, with which the sympathetic has numerous communications. Most of the physiological variations in the calibre of the vessels are brought about by reflex action, and the reflex centres are situated in the cord and medulla. From these centres there seems to pass a continuous slight stimulation inducing that moderate contraction which we name **Tonicity**. If the connection be severed the tonicity ceases, the arteries dilate. There is a general centre for the whole vaso-motor system in the medulla oblongata. When this is stimulated the arteries throughout the body contract. When it is destroyed the arteries in the body dilate. But without being destroyed the centre may be paralyzed or inhibited. It is inhibited by the inhalation of nitrite of amyl, and the arteries dilate. It may also be inhibited by the stimulation of a nervous branch which passes upwards from the heart, the depressor nerve. This general centre, therefore, has nervous connections of a kind similar to the local ganglia.

Literature.—A very good historical account of the physiology of the vessels is that in Von Recklinghausen's Handbuch der allgemeinen Pathologie, 1883, p. 4, *et seq.* See also Hunter, On the blood, inflammation, and gunshot wounds, 1793, Palmer's ed., vol. iii., p. 145; Henle, Pathologische Untersuchungen, 1840; Handbuch d. rationellen Pathologie, 1846; Bernard, several series of Leçons, 1858-1876; Lister (who inferred the existence of peripheral ganglia), Phil. Trans. for 1858, vol. cxlviii.; Waller, Proceedings of Roy. Soc., 1862. Cyon & Ludwig, Ludwig's Arbeiten, 1866 and 1867; Vulpian, Leçons sur l'appar. vasomot., 1875; Stilling, Jenaische Annalen, 1851. Saviotti, Virchow's Archiv, l., 1870; Golz, Virchow's Archiv, vols. xxvi., xxviii., and xxix.; Krehl, Patholog. Physiologie, 1898; Von Basch, Allgem. Physiol. u. Pathologie des Kreislaufes, 1892; Thoma, Pathol. Anatomie, i., 1894, also Trans. by Bruce, 1896; Lukjanow, Allgem. Pathologie d. Gefassystems, 1894.

LOCAL HYPERÆMIA.

This term is applied to conditions in which the vessels, and especially the capillaries, contain an excess of blood. Two forms are distinguished according as, on the one hand, the blood is too freely admitted by the arteries, or, on the other, meets with some obstacle to its passage by the veins. These are called respectively active or arterial and passive or venous hyperæmia.

I.—ACTIVE OR ARTERIAL HYPERÆMIA. ACTIVE CONGESTION.

This occurs when an excess of blood is admitted by the arteries into a part. The terms **atonic** and **arterial hyperæmia** are synonymous with active hyperæmia, as are also **fluxion** and **determination of blood.**

Causation.—Active hyperæmia is brought about chiefly by causes which induce dilatation of the arteries, although a local increase of blood-pressure, by forcing more blood into the arteries, will have a similar effect.

Local increase of blood-pressure is not of frequent occurrence, because as a general rule the vessels are so completely under the regulation of the nervous system that a rapid accommodation is readily effected by contraction of the arteries. If the arteries be diseased, however, so that their walls are rendered rigid (as by atheroma) then variations in blood-pressure will not be readily compensated. Hence in people whose cerebral arteries are atheromatous, temporary increase of blood-pressure may cause congestion of the brain.

Collateral hyperæmia might be supposed to be due to a local increase of blood-pressure. It occurs when in consequence of obstruction of an artery, or otherwise, the blood supply is diminished in one locality, with the result that there is an increase in the amount of blood in another, generally a neighbouring locality. Doubtless an obstruction in an artery leads to increase of pressure in the arteries proximal to the obstruction, and there may be a resulting hyperæmia of neighbouring parts which will assist in establishing an anastomotic circulation. But the problem is not always so simple as this. The arteries are so completely under the command of the nervous system that the site of the collateral hyperæmia is frequently at a certain distance from that of the anæmia, and is determined not by increase of blood-pressure but by relaxation of arteries. Thus obstruction of one renal artery will induce collateral hyperæmia in the kidney of the opposite side.

Dilatation of arteries so as to lead to active hyperæmia is brought about in several different ways. It may be due to purely local causes, or to an action on the vaso-motor nerves or vaso-motor nerve-centres.

As examples of dilatation of arteries from Local causes may be cited cases in which the sudden withdrawal of pressure induces local hyperæmia. When the abdomen, for instance, is the seat of a collection of fluid, pressure is exercised on the vessels, and the arteries will relax as completely as possible to allow the blood to overcome the pressure from without. But if the fluid in the abdomen be suddenly removed, the pressure outside the vessels will be greatly reduced, and, till the arteries have time to contract, there will be an active hyperæmia. This effect of the sudden removal of pressure is generally, at least in part, obviated by the application of a bandage. On similar principles removal of large ovarian tumours that have pressed on the kidneys and renal arteries sometimes leads to active hyperæmia of the kidneys, which may be accompanied by albuminuria.

Other examples of active hyperæmia due to local causes are afforded by the application of warmth to the surface of the body as by poultices, the result being a direct dilatation of the cutaneous arteries. Mechanical irritation of the skin, as by stroking it, usually induces, first a contraction of the arteries, evidenced by paleness, and then a dilatation, shown by a red streak. Similarly, chemical irritants produce dilatation, sometimes preceded by contraction, the dilatation leading to active hyperæmia, which, in this case, may be the first phenomenon of inflammation. Again a mere temporary deprivation of blood may induce dilatation of arteries and a local hyperæmia. Thus in surgical operations, when the circulation has been suspended by the application of an elastic bandage, the removal of the latter is often followed by an active hyperæmia.

Active hyperæmia due to causes influencing the **Vaso-motor nerves** may be produced by paralysis of the vaso-constrictors or by irritation of the vaso-dilators. Injury or disease of the sympathetic nerve in the neck is sometimes followed by unilateral congestion of the face, and by unilateral sweating, together with narrowing of the pupil, smallness of the eyeball and ptosis, these all being signs of paralysis of the sympathetic.

Such cases have been described by Weir Mitchell and others as following gunshot wounds, etc., and by Hutchinson as the consequences of fractures of the clavicle; some of the manifestations, at least, may ensue from the pressure of tumours, or aneurysms, or the extension of abscesses, tuberculosis, etc., to the neighbourhood of the sympathetic in the neck.

In certain forms of neuralgia, especially in hemicrania, the phenomena indicate first an irritation and then a paralysis of the vaso-constrictors. Du Bois-Reymond by analysis of his own symptoms in such attacks came to this conclusion. In his case there was redness of the external ear; in other cases redness of the retina has been observed. The temperature as tested by the thermometer, in the external meatus, is usually raised, both in the neuralgic cases and those due to injury.

There are comparatively few cases of active hyperæmia which can be directly referred to irritation of the vaso-dilators, but after wounds of nerves, there sometimes occur during the process of healing, severe attacks of pain accompanied by redness and elevation of temperature, which seem only explicable on the supposition that the vaso-dilators are irritated. These phenomena are sometimes followed by trophic disturbances, more particularly the "glossy skin" of Paget.

Paralysis of **Vaso-motor centres** is calculated to induce active hyperæmia if the dilatation of the arteries be localized. Thus in a case observed by the author there was a traumatic lesion of the medulla oblongata which injured the vaso-motor centres of the kidneys. The result was an intense hyperæmia of both kidneys, visible after death, and manifested during life by an excessive secretion of watery urine. During the few hours of life a large quantity of urine was twice removed by catheter, and after death the bladder was found greatly distended. Some authors ascribe diabetes mellitus to paralysis of the centres in the medulla oblongata, or in the semilunar ganglia. Such a paralysis would induce congestion in the abdominal organs, and more especially in the liver.

Phenomena of active congestion.—When a local dilatation of the finer arteries of a part occurs, the most direct result is that the blood is admitted more freely, and at an accelerated rate. It meets with less resistance in the arteries, and reaches the capillaries and veins at a higher pressure than normal. The part so affected is of a bright red colour, and, if it be an external part, its temperature is raised. In many cases the active congestion is of short duration, but if it continue it leads commonly to more definite changes. There is increased transudation from the vessels, and consequent swelling. The secretion of the part is increased. This has been observed more particularly in the case of the secretion of sweat; unilateral hyperæmia and sweating have been ascribed to pressure on the sympathetic by an aneurysm (Gairdner) or a tumour (Ogle and Verneuil). There may also be considerable hypertrophy in consequence of active hyperæmia. (See Hypertrophy.)

It has been said that active hyperæmia may lead to hæmorrhage, but experiment seems to prove that even a very great rise in the blood-pressure in the capillaries does not lead to hæmorrhage, unless the vessels are badly supported, or else defective in some way. By obstructing the respiration in a dog the arterial pressure may be raised enormously, but there is no rupture of the capillaries, or only in such delicate structures as the retina, brain, or conjunctiva, or in the pleura and pericardium, where, on account of the violent and abortive efforts of inspiration, a partial vacuum is produced, and the vessels are ill-supported. The increase in pressure in a pure active hyperæmia is, of course, greatly less than this.

Literature.—WEIR MITCHELL, MOREHOUSE, and KEEN, Gunshot wounds and other injuries of nerves, 1864; HUTCHINSON, Lond. Hosp. Reports, 1866; WEIR MITCHELL, Injuries of nerves and their consequences, 1872; DENMARK, Med. Chir. Trans., iv.; PAGET, Med. Times and Gaz., 1864; BERGER (Hemicrania), Virchow's Archiv, vol. liv., 1874; GAIRDNER, Clin. Med., 1862, p. 557; VERNEUIL, Gaz. des hôpit., 1864; BIER, Collateralkreislauf. Virch. Arch., 147, 1897 (with literature); LÖWIT, Centralb. f. allgem. Path., viii., 1897.

II.—PASSIVE OR VENOUS HYPERÆMIA OR PASSIVE CONGESTION.

This is a condition in which the blood stagnates in the vessels; they are overfilled with blood which, as it remains too long in the vessels, has a venous character, hence passive hyperæmia is also called Venous Hyperæmia.

Causation.—Passive hyperæmia frequently occurs as a consequence of **Weakness of the heart.** In the normal state the forces of the circulation in order to remove the blood from depending parts, have to overcome gravitation. The force of the heart propagated through arteries and capillaries to the veins is generally sufficient to do this. It is, however, assisted by the muscular movements, which, in conjunction with the valves in the veins, materially assist the venous current; also by the aspiration effected by the inspiratory movements. But if the heart is weak, the blood is apt to linger in depending parts or in parts far removed from the centre; hence the name **Hypostasis** or **Hypostatic hyperæmia** applied to such conditions. Weakening of the heart occurs in many forms of disease. It is often very marked in fevers, such as typhus and typhoid, or in long-continued debilitating diseases, which produce anæmia. In these cases the blood often stagnates in the dependent parts of the lungs, or in depending parts of the skin, over the sacrum and shoulder blades in persons lying on their backs, over the trochanters in persons lying on their sides. In these latter situations the weakness of the circulation along with the mechanical effects of the weight of the body and the irritation of decomposing material, lead frequently to necrosis of the skin and the formation of bed-sores. In fevers there may be passive hyperæmia of the extremities of the fingers or toes, resulting even in necrosis or gangrene.

Again, there may be difficulty in overcoming gravitation on account of the force of the heart being partly lost by reason of **Obstruction of arteries.** Thus atheroma, by producing a thickening of the internal coat, may cause a partial obstruction, which is often increased by the formation of thrombi on the affected surface. In consequence of this, the force of the heart may be insufficient and the blood may stagnate in the parts supplied. Complete occlusion of an artery will under certain circumstances produce extreme passive hyperæmia. (Hæmorrhagic infarction, see under Embolism.)

Obstruction of veins is the most direct and obvious cause of passive hyperæmia. This may be produced by pressure of tumours, exudations, bandages, the pregnant uterus, even hard masses of fæces, by coagulation of blood within the veins, or by the bursting of tumours into veins, or their growth through their walls.

Lastly, **Disease of the valves of the heart** produces in a large proportion of cases a general venous hyperæmia (see under Heart).

Phenomena of passive hyperæmia.—Taking the simplest case, that of obstruction of a venous stem, the first result is an increase of blood-pressure in the veins behind the point of obstruction, and an accumulation of blood in the part. If the veins have abundant anastomoses, then the blood will soon to a considerable extent find its way by other channels and the normal conditions be restored. But from the list of causes of passive hyperæmia it will be seen that most of these involve sets of veins, or whole regions of the body; even in the case of thrombosis, the coagulation usually extends to a number of veins; hence, relief by anastomosis may not be obtained. The local increase of pressure remains, and it affects capillaries.

The further effects are to be traced to the excessive pressure of the accumulated blood in the capillaries and to the nutritive changes in their walls from the stagnation of the blood. The blood accumulates in excessive quantity in these vessels and at an excessive pressure. In consequence of this an increase in the natural transudation of fluid through the capillaries occurs, and the blood-corpuscles, especially the red ones, escape from the vessels. Each of these phenomena merits more special consideration.

Hæmorrhage by diapedesis is the escape of the red corpuscles from the blood-vessels without rupture of their walls. This process occurs mainly, if not entirely, in the capillaries, and it can be shown by experiment that it does not involve rupture of these vessels. If the tongue of a frog is ligatured at its base so as to include all the veins, but excluding the artery, there will be the phenomena of hyperæmia greatly intensified, and amongst these phenomena diapedesis. But if the ligature be loosened within a moderate period, the circulation is restored, and the phenomena disappear. If the escape of blood-corpuscles had been by rupture, it would have continued after resumption of the circulation. As to the manner in which corpuscles escape, it is probable that they pass between the endothelial cells. Fig. 18 shows the appearance of the endothelium of a capillary mapped out by treatment with nitrate of silver, and Fig 19 shows capillaries similarly treated after passive hyperæmia had existed. The latter illustration is taken from Arnold, who asserts that while in the normal condition there are minute apertures between the endothelial cells, chiefly at the angles where two or three meet, these are found much enlarged in passive hyperæmia. The small apertures may be called stigmata, and the larger ones stomata. The excessive pressure in the capillaries seems to be the chief agent in causing the escape of the corpuscles as well as the increased transudation of fluid, but we have also as a considerable element, in many cases, a nutritive defect in the walls of the vessels from their long exposure to venous blood, allowing of the escape of the corpuscles. The hæmorrhage is usually inconsiderable, but in some cases it attains to large dimensions. (See under Thrombosis of cerebral sinuses.)

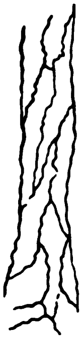

Fig. 18.—Normal capillary, with endothelium mapped out by treatment with nitrate of silver.

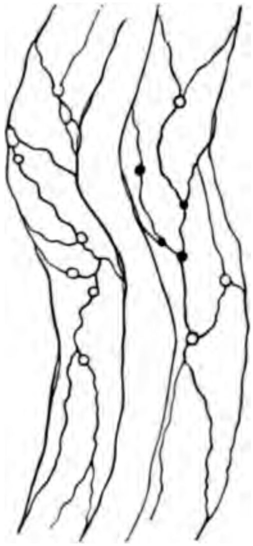

Fig. 19.—Capillaries after passive hyperæmia. Apertures between the cells greatly enlarged; the so-called stomata. (ARNOLD.)

The author has observed of late a loose way of using the term diapedesis by applying it to the emigration of the leucocytes. As this use is confusing and is opposed to the original employment by Stricker, Cohnheim, Arnold, and others, to designate a form of *hæmorrhage*, it seems unadvisable. The author therefore limits the term to the escape of red corpuscles without rupture, reserving the term emigration for the more active penetration of the white corpuscles.

That there is an increased **Transudation of fluid** can be directly proved by experiment. The flow in the lymphatic vessels has been proved to be excessive. If the lymphatics are not capable of disposing of the entire excess, then the fluid accumulates in the serous spaces and cavities of the body, giving rise to **Œdema and Dropsy** (see further on). This accumulation will occur if, on the one hand, the transudation be too great for the lymphatics to dispose of it, or if, on the other, for some reason, the lymphatics do not take it up sufficiently. The current in the lymphatics depends on the blood-pressure, and we have just seen that the cause of the increased transudation is excess of blood-pressure, and so the same condition which determines the increase will, to a certain extent, cause it to be more rapidly disposed of. In cases of **hypostasis**, however, there is a special tendency to œdema. The hyperæmia here is due, as we have seen, to weakness of the heart associated with the action of gravitation. Both of these causes will equally act on the lymphatic circulation, and induce the transuded fluid to linger and accumulate.

The exuded fluid, as may be inferred, contains red corpuscles, but it does so to a much less extent in actual pathological conditions than might be supposed from experiments in animals. In the latter there is a sudden obstruction, with exaggerated results; in actual disease in man the processes usually develop slowly, and there is some accommodation of the vessels. It should be added that the white corpuscles pass out of the vessels as well as the red, but not to such an extent, and that the corpuscles, both red and white, escape from the small veins as well as from the capillaries.

The part which is the seat of passive hyperæmia is unduly red, and the tint is dark or livid, hence the term **Cyanosis**, which is applied when the lividity is extensive. The part is swollen, both from the over-filling of the vessels and from the œdema, and is usually lowered in temperature. In organs readily capable of increase in bulk, there may be considerable **Enlargement** as a result of passive hyperæmia. This is especially the case in the spleen.

Two other consequences frequently follow in prolonged passive hyperæmia. The distended capillaries exerting pressure on the surrounding structures may through time produce **Atrophy.** This is seen especially in passive hyperæmia of the **liver**, where the central parts of the lobules often show a striking absence of hepatic cells. It is also seen in the kidney and the retina.

An opposite result is often effected by prolonged passive congestion, namely, **Hypertrophy of the connective tissue**, induced by the increased transudation which bathes this tissue. The hypertrophied connective tissue is dense, and it gives increased density to the organs affected, hence the term **Cyanotic induration.** This is very common as a result of valvular disease of the heart and is seen in the heart itself, the lungs, kidneys, liver, etc. In the lungs the induration is associated with pigmentation, due to the hæmorrhage by diapedesis, hence the term **Brown induration.**

Necrosis or death of parts is not a common result of passive hyperæmia. It occurs when the conditions are such as to produce complete stagnation of blood. If a loop of intestine be caught in a hernia in such a way as to obstruct all the veins, then passive hyperæmia may be followed by gangrene. Similarly ligature of the femoral vein or its obstruction by a tumour may produce gangrene, as this vein has few and insufficient anastomoses. This only occurs if the vein be suddenly obstructed.

Literature.—For a good account of passive hyperæmia from experimental side, see COHNHEIM'S Allgem. Pathologie, 2nd ed., vol. i., p. 138. See also RECKLINGHAUSEN, Allgem. Path., p. 28; ARNOLD, Virchow's Archiv, lviii., 1873; ZIELONKO, *ibid.*, lvii., 1873; LAZARUS-BARLOW, Manual of General Pathology, 1898.

LOCAL ANÆMIA OR ISCHÆMIA.

These terms designate the condition in which the blood-vessels, and in particular the capillaries, are more or less empty of blood, and the part is correspondingly pale.

Causation.—The vessels, and especially the capillaries, may be directly emptied by pressure from without. We have an artificial anæmia produced in this way by Esmarch's elastic bandage. A tumour or an abscess may by pressure empty the vessels, and, if long continued, this may lead to necrosis of the structure concerned. In most cases, however, anæmia is due to obstruction of arteries, but such obstruction rarely produces ischæmia unless it be comparatively sudden and tolerably complete.

Spasms of arteries, that is to say, violent contraction of their middle coat, may cause such obstruction as to produce an extreme anæmia. The application of cold to the skin causes contraction of the cutaneous arteries—ether spray causes a striking anæmia by this means. The rigor at the beginning of many fevers, accompanied as it is by paleness and coldness of the surface, is due to spasm of the cutaneous arteries. Some neuralgias are associated with spasm of arteries. (Du Bois-Reymond.) In some persons the vaso-motor system is peculiarly sensitive, and slight causes are sufficient to induce spasm of the arteries and a local anæmia.

A series of phenomena produced by prolonged spasm of arteries is grouped under the name of **Raynaud's disease**, from the writer who first gave a full description of these phenomena. In predisposed persons an ordinary exposure to cold, as in washing, will induce such a spasm as to render the fingers bloodless and anæsthetic; they are said to be "dead" (*local syncope*). In more severe cases the skin becomes dark blue and various eruptions may form (*local asphyxia*). In very severe cases there may be actual necrosis of the ends of the fingers and toes. This form of disease is symmetrical.

A sudden obstruction of an artery by **Embolism** is a frequent cause of Ischæmia, but this frequently gives place to a passive hyperæmia. (See under Embolism.) The **ligature of an artery** or a sudden compression will also lead to local anæmia.

Disease of the walls of arteries is not a frequent cause of ischæmia, as obstruction from such conditions as atheroma is frequently very partial, and even when considerable is of slow production. Hence such conditions more frequently lead to passive hyperæmia in the way already mentioned.

Phenomena and results.—In the anæmic part the capillaries are imperfectly filled, and the blood current is slow. The part is consequently pale, reduced in temperature, flaccid. Its nutrition is diminished, and its elements are prone to undergo atrophy and degeneration, or even, as we have already seen, necrosis. The function will be interfered with if the nutrition is diminished, and if the anæmia affect an important organ, the results may be serious. Thus, obstruction of the coronary arteries may cause death by paralysis of the heart. Lastly, a local anæmia may produce hyperæmia elsewhere—a collateral hyperæmia.

Literature.—Recklinghausen's Handbuch, p. 35; Virchow, Handbuch d. spec. Path. und Therapie, vol. i.; Raynaud, De l'asphyxie locale et de la gangrène symétrique, 1862; and Arch. gén. de méd., xxiii., 1874; Du Bois-Reymond, Arch. f. Anat. und Physiol., 1860; T. K. Monro, Raynaud's disease, 1899.

THROMBOSIS AND EMBOLISM.

These two conditions are often associated, but must be carefully distinguished. Thrombosis is the coagulation of blood within the vessels or heart. Embolism is the obstruction of a vessel by a plug brought from a distance. The coagulum which forms in thrombosis is a **thrombus**, the plug which obstructs in embolism is an **embolus**. A thrombus detached from its place becomes an embolus, and an embolus, whether consisting of coagulum or not, may grow by successive deposition of clot, that is to say, by thrombosis.

I.—THROMBOSIS.

In considering the mode of occurrence of thrombosis, it is necessary to refer to the **Coagulation of blood.** According to the views which are identified with the name of Alexander Schmidt (although Andrew Buchanan anticipated many of his results) three agents are necessary for coagulation, the fibrinogen, the fibrino-plastic substance or paraglobulin, and the fibrine ferment. The two former unite to form fibrine in the presence of the latter. The fibrinogen is dissolved in the blood-plasma; the paraglobulin, at least chiefly, and the ferment, entirely, reside in the white corpuscles. More recent observations seem to have modified this view, and it now appears that coagulation occurs by the conversion of the dissolved fibrinogen into insoluble fibrine, this being effected by means of the fibrine ferment which resides in the leucocytes. A third element however is still necessary, namely, the presence of a salt of calcium without which coagulation does not occur. From the blood-plasma a nucleo-albumin can be separated. This, when brought into contact with a solution of fibrinogen and calcium salts will induce coagulation. According to Pekelhäring and others the fibrine ferment is to be regarded as a compound of nucleo-albumin and calcium. When brought into contact with fibrinogen the calcium unites with part of the fibrinogen molecule, and the result is fibrine. Fibrine thus, according to this theory, is an insoluble albuminous calcium compound. The nucleo-albumin resides in the white corpuscles, and passes into solution when these disintegrate. It is only by destruction of the white corpuscles that the ferment is set free; so long as the white corpuscles circulate in the blood and remain alive fibrine cannot form. Fibrine will form when the conditions are such that the white corpuscles are no longer preserved alive. Fibrine, it will thus be seen, is the result of a chemical process, and the resulting substance, the fibrine, is not a vital structure, but a dead chemical compound. The white corpuscles must not be exposed to the contact of dead matter if they are to be preserved. You may keep blood fluid for a long time if you simply insure that it is in contact with living tissue. Lister long ago showed that if an artery be ligatured in two places and cut out while full of blood, it may be hung up and the blood will remain fluid for some days. Within the body if a vessel be ligatured carefully in two places, the middle portion remaining in connection with the living tissues, then the blood may be kept fluid from twelve to fifteen days. When blood is exposed to a perfectly smooth surface, even if it be of dead matter, it does not coagulate readily. Thus a piece of glass in the circulating blood does not induce coagulation, and blood in a vessel whose internal surface is smeared with oil does not readily coagulate.

It appears from the observations of Rauschenbach that the cells of lymphatic glands when treated with water yield, like leucocytes, the ferment necessary for coagulation. Most other cells probably possess a similar power. Foà and Pellacani assert that when fresh brain substance is treated with water and filtered, the filtrate injected into the jugular vein of rabbits induces rapid coagulation.

Bizzozero asserts that it is the blood-plates and not the leucocytes which have to do with coagulation. He would adopt the view given above of this process, substituting the blood-plates for leucocytes. In the observations of Wooldridge, a deposition of small granules was observed apart from ordinary coagulation, and he regarded these as composed of a form of Fibrinogen (A Fibrinogen). Löwit, on the other hand, holds that the granules are composed of globulin, and are due partly to disintegration of the leucocytes and partly to precipitation from the plasma. It may be concluded that, besides the process of coagulation described above, and without such coagulation, the blood is capable of depositing solid granules which have in the mass the characters of fibrine, and give the same reaction as fibrine with Weigert's stain (Löwit). This occurs very rapidly whilst blood is cooling, and can scarcely fail to occur when blood from the living body is examined in the ordinary way by placing a drop on a glass slide and covering it with a thin cover glass. It occurs also by mechanical interference with the blood.

In connection with this whole subject, the alleged rapid disappearance of leucocytes when the blood is shed is of interest. Löwit asserts that by examining the blood removed from the living body in warm oil on a warm stage he prevents, at least in part, the disintegration of the leucocytes and the appearance of the disclets. His enumerations by this method seem to show that the leucocytes are much more numerous in the normal blood than they appear in an ordinary preparation, the numbers in the latter case being 80 per cent. fewer than in the former. These observations confirm the views held by Cohnheim, Schmidt, and others.

The Process of thrombosis.—If a portion of blood inside a vessel be cut off from the circulation, then it will by and by coagulate just as it does outside the body, a leading factor in the coagulation being the disintegrating white corpuscles. In this way a **Red thrombus** is produced. But vessels are rarely so situated as to allow of a complete coagulation such as this; much more frequently the thrombus is formed from the blood which is still moving, although it may be slowly, and it is of gradual growth. The formation of thrombi in the living vessels has been carefully studied by **Zahn**, whose **experiments** throw much light on the process.

The mesentery of a frog is exposed and subjected to microscopic examination. A vessel of some size, an artery or vein, is chosen, and its wall in some way injured, as by twitching it slightly with the forceps, or placing a small crystal of common salt near it. Very soon white blood-corpuscles begin to adhere at the injured part. As the blood passes over it successive layers of white corpuscles adhere, and a growing clump of them is formed. Along with the white corpuscles a stray red one may be insinuated, or there may be several red ones. The clump so formed, be it wholly white or partly mixed with red corpuscles, may be carried off, in which case a new one begins to form; but the clump may remain fixed and be continuously enlarged by successive depositions of corpuscles from the circulating blood. In course of time a change occurs in the appearance of the clump, the white corpuscles lose their individual outline to a great extent, and the clump gathers itself together into a grey granular mass in which neither by acetic acid nor by staining are the majority of the white corpuscles to be discovered. It has, indeed, very much the characters of fibrine which has been obtained by whipping the blood outside the body. The clump of white corpuscles, in fact, by the disintegration of the corpuscles and the attraction of the fibrinogen from the blood-plasma has converted itself into a fibrinous coagulum. All the white corpuscles, however, are not disintegrated, some are still recognizable in the mass. A similar mode of formation is observed when a vessel is injured by pricking with a needle, or by cutting it. The presence of foreign bodies, if they are rough on the surface, produces adhesion of white corpuscles and their conversion into thrombi in similar fashion. The thrombus formed in these various ways is called by Zahn the **White thrombus**.

Eberth and Schimmelbusch, from a very elaborate series of observations, have come to several very important conclusions. They assert that Zahn's observations are correct with the exception that it is the blood-plates and not the leucocytes which go to form the white thrombus. They do not regard the process as one of coagulation, but rather of conglutination; that is to say, the clumps of blood-plates run together and form white masses, in which no proper fibrine is present. When a foreign body, such as a thread, is introduced into the circulation then true fibrine is deposited, but not in the simple white thrombus. Leucocytes are often caught in the thrombi, in which they may be present in larger or smaller numbers. These observations are explained and amplified by the researches of Wooldridge and Löwit above referred to. We may now say that an injury to the wall of a vessel causes the deposition of granules of solid matter from the blood, and that these granules have the characters of fibrine.

In actual pathological processes in the human subject the pure white thrombus is frequently seen, especially in the heart, but it is more frequently mixed. As a general rule the thrombus enlarges by fresh deposition, and it not infrequently happens that, as corpuscles accumulate, sufficient ferment is produced to allow of the coagulation of a layer of entire blood. Hence strata of red coagulum may alternate with strata of white. Again the thrombus after its formation may become compacted into a dense white structureless layer having a hyaline appearance, and composed of fibrine which adheres to the wall, and is so united that its boundary is indefinite; the fibrine is sometimes traversed by canals (channelled fibrine). This condition is often seen in the external layers of clot in aneurysms. We may thus distinguish four forms of thrombus according to structure. (1) The **red thrombus**, composed of the entire blood; (2) the **white thrombus**; (3) the **stratified** and **mixed thrombus**; and (4) the **hyaline thrombus.**

The main cause of coagulation, then, is the contact of the blood with dead matter or altered living tissue. In the living body anything which interferes with the integrity of the vessel-wall or the endocardium is likely to predispose to coagulation. Stagnation of the blood is often set down as a cause of coagulation, but this will act chiefly by altering the vessel-wall, and by keeping the white corpuscles removed from contact with the living tissue. As it is the endothelium of the vessels and endocardium which is in most immediate contact with the blood, it will be interferences with it that will conduce to coagulation.

Causation.—In most cases of thrombosis there is either a **stagnation of the blood** or else some **palpable injury to the vessel** compromising its endothelium, and the various thrombi may be studied according as they are formed in one of these ways or the other, while in some cases the action of both may be traced. As we have already seen, the stagnation is rarely complete, and accordingly the thrombi are mostly white or mixed, being formed in the way just described.

(*a*) **Thrombosis from stagnation of blood.**—It will be found that wherever the circulation is so altered that, while the blood moves more or less freely in the general current, there are subsidiary currents or eddies, thrombosis is liable to begin in the situation of the latter. **Local dilatations** produce this very directly. In cases of aneurysm or varix there is a pouch containing blood which is out of the regular current and thrombosis is liable to occur, although in the case of aneurysm there is the additional fact that the wall is considerably altered. **Weakness of the heart**, especially when associated with dilatation, leads to imperfect emptying of its cavities, and the blood forms eddies in the parts most removed from the general current (see Fig. 20). White thrombi often form in this way behind the columnæ carneæ, in the auricular appendages, and near the apices of the ventricles. These thrombi often assume a globular shape (Globular vegetations of Læннec), and may grow to a large size. **General weakness** or **marasmus**, occurring in consequence of debilitating diseases, such as typhoid fever, phthisis, influenza, etc., renders the current in the veins sluggish. The thrombi resulting are often designated **marasmic or marantic thrombi.** There is under these circumstances not only weakness of the heart, but the muscles being weak do not assist in emptying the veins, and respiration also fails to give due assistance. While there is a general sluggishness, the localities in which the thrombosis begins usually correspond with bye currents in the circulation. The blood in the veins moving slowly and at a low pressure does not press back the valves against the walls of the veins. Hence as the valves are half open, the blood will stagnate **in the sinuses** of the valves, and thrombosis is liable to occur there. Coagula so formed grow up the veins, but even when they are continuous they usually present a knotted character from the parts corresponding with the valves being bulkier. This knotted condition is sometimes detectable through the skin. Again marasmic thrombi often begin in the **longitudinal sinus** of the dura mater. This vessel has somewhat rigid walls, and the tributary veins from the pia mater are small, and in the erect posture the blood passes upwards to the sinus against the force of gravitation. If the current in the veins be slow then there will be eddies in the sinus, especially at the parts lying highest. The most common starting point is indeed the highest part of the sinus (Recklinghausen). Thrombosis in the **uterine veins** after delivery is partly due to stagnation of blood in cases where the uterus contracts imperfectly, but the injury to the veins in the removal of the placenta

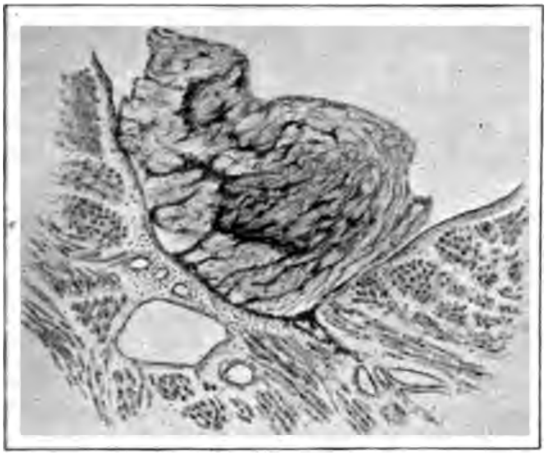

Fig. 20.—Thrombus in auricle of heart. The muscular tissue of the heart is shown in longitudinal and transverse section, and, lining it, the endocardium. The thrombus bulges out from a recess. ×42.

contributes. In many instances of thrombosis, designated marantic, other factors are in operation and in some of these the thrombosis is evidently part of an infective process.

(*b*) **Thrombosis from alteration of the wall.**—Wounds of vessels induce thrombosis, and this process bears an important part in stilling hæmorrhage. If the blood is stagnating in the veins, as is the case in passive hyperæmia from heart disease, a trivial wound may start a thrombosis. Thus, in cases of valvular disease the legs are not infrequently punctured to relieve the œdema which is so common in such cases, and the punctures may be the starting points of thrombosis. Ligature of vessels causes thrombosis, as there is rupture of the internal and middle coats. Acute inflammation of the walls of the heart or vessels induces coagulation, as one sees so frequently in acute endocarditis. The vegetations on the valves are essentially thrombi. Chronic endocarditis and atheroma, by producing palpable alterations in the endocardium or internal coat of arteries, are frequent causes of thrombosis, more particularly when calcareous matter is deposited and becomes exposed to the blood. An occasional cause is the protrusion of tumours through the walls of vessels, but this scarcely ever occurs in arteries and is rare in veins.

(*c*) There are cases in which coagulation occurs apparently in consequence of the sudden setting free of the ferment in the general circulation. This has been mostly in cases of transfusion, where blood from one of the lower animals has been used. The instances of widespread and sudden thrombosis in cases of large and severe burns and in snake-bite probably fall into this category.

It is important to distinguish **Thrombi** which have formed during life from mere **Post-mortem Coagula**. It will be clear from what has gone before that the thrombi are mostly either white or grey, but being formed largely of white corpuscles they are of a dead or **opaque white** or **grey** appearance. Post-mortem clots are sometimes pale from the sinking of the red corpuscles or otherwise, but they are gelatinous and smooth on the surface and mostly translucent, whereas the thrombi are firmer, drier, more opaque and granular on the surface. The thrombi also adhere to the wall to some extent, whereas the clots do not, although in the heart, from getting entangled among the columnæ carneæ, they may have an appearance of adhesion. Lastly, the thrombi are often stratified, indicating their deposition in successive layers.

Growth of thrombi.—Thrombi begin as local depositions on the internal surface, but they are liable to grow till they may fill the vessel, obstructing it and extending to further portions of the vessel. The thrombus is composed of dead matter, and its surface is rough, so that the conditions are given for further deposition, unless the current is rapid. The influence of the blood-current in determining the extension of thrombosis is well shown in the case of ligature or severance of arteries as in amputations. The accompanying illustration (Fig. 21) shows a section of a small artery from a stump. It was not ligatured, but its mouth is filled with a thrombus which extends exactly to the first branch proximal to the plug, or to the point where the circulation becomes active. In the case of the veins the blood will be for the most part stagnant above and very often below the thrombus, and it is in these vessels particularly that thrombi are apt to grow very extensively. Thus a coagulation starting in the uterus may travel along to the internal and common iliac veins, and thence pass into the veins of the legs. In a case observed by the author, coagulation had its origin in a cancer of the kidney which involved the walls of the renal vein; it extended thence to the inferior vena cava, and to the veins of both legs which were distended with old thrombi. Thrombi in the veins will often be found growing on till

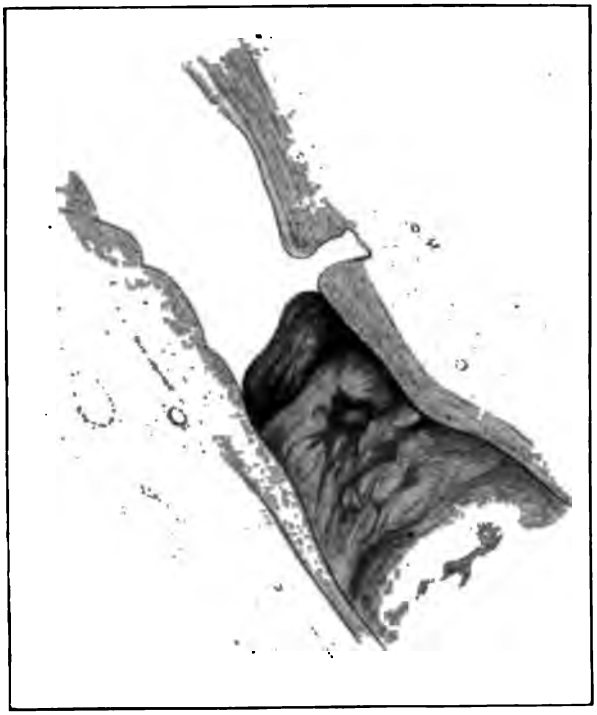

Fig. 21. Section of a small artery from a stump. The bleeding has been stopped by a thrombus without ligature. The thrombus comes accurately to the level of a branch going off to the right. × 6.

they reach a vessel where the circulation is very free, and the globular thrombi in the heart often grow so as to project into the cavity. Growing thrombi will be mostly white or mixed, but as the blood above and beneath an obstructing thrombus is usually at a stand-still or nearly so, they may be almost purely red in parts.

Before leaving this subject, it may be well to consider **Whether thrombosis occurs in the living capillaries.** It is to be remembered that, so long as the living endothelium exercises its due influence on the blood, coagulation will not occur. As the capillary wall is entirely composed of flat cells, it is only when necrosis takes place, as seen, for example, in infarction, that the conditions requisite for coagulation will be fulfilled. Moreover, as the tissues depend on the capillaries for their nutrition, obstruction by thrombosis will involve the death of the tissues themselves. Hence thrombosis of the capillaries, or even complete stagnation in them, may be put out of the question except in connection with necrosis. If this were not so, the thrombi in veins would grow into the capillaries, and, through them, into the arteries. The capillaries, not admitting of this, form a barrier to the extension of the coagulation. An exception to this general rule is to be found in certain toxic affections in which a peculiar form of hyaline thrombosis is met with in the capillaries as well as in the smaller vessels. It thus happens that, after extensive coagulation in the veins, the circulation is largely maintained by arteries, capillaries, and lymphatics, and necrosis rarely occurs. It is worthy of note in connection with this matter that the blood found in the capillaries after death is nearly always fluid.

Changes in Thrombi.—If a thrombus contains red corpuscles, then their colouring matter is soon dissolved out and stains the coagulum, giving it frequently a deep brown tint. The pigment sometimes deposits crystals of hæmatoidin, which may remain long unaltered. (See Fig. 22.) In course of time further changes occur, of which the more important are softening and organization.

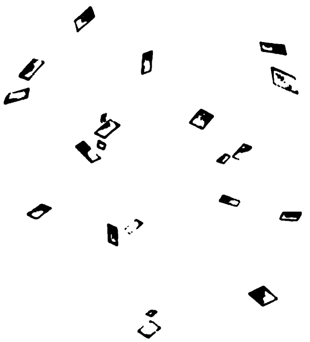

Fig. 22.—Crystals of hæmatoidin found closely aggregated in the midst of an old thrombus in a vein. The crystals have a deep red colour. ×350.

Softening is a frequent result, especially in the coagula in the heart and veins. The globular thrombi in the heart frequently exhibit this process. (See under Heart.) It begins in the central parts of the thrombus, and the coagulum breaks down into a turbid brownish juice, the softening extending gradually outwards. The juice is often like a mixture of pus and blood, or in very white thrombi it may be like pure pus. It consists of the debris of the thrombus, and no well preserved corpuscles are to be found in it. The softening may extend outwards till a mere rind is left, and this may give way and cause the juice to be launched into the circulation. Another form of softening is that which occurs in thrombosis due to septic infection, in the condition known as Thrombo-phlebitis.

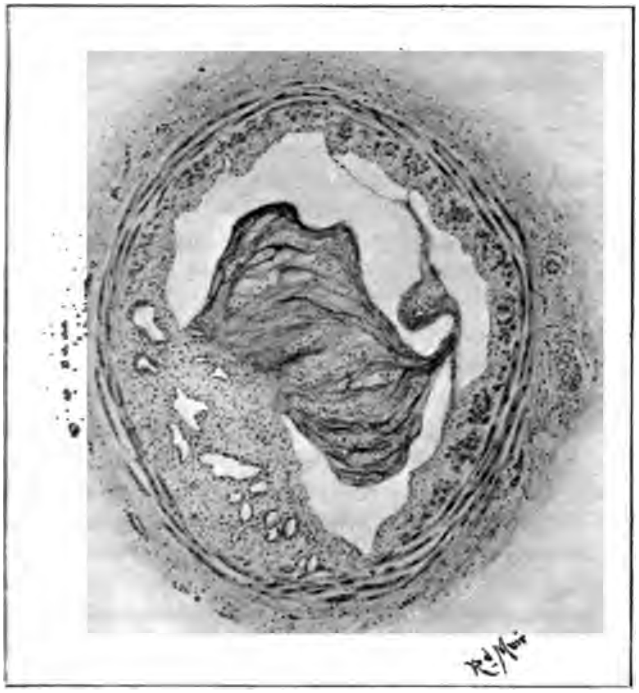

Fig. 2[illegible].—Commencing organization of a thrombus in a vein. Encroachment on thrombus by new-formed vascular tissue. × 25.

Thrombi, instead of softening, may dry in and shrivel. In such cases we may have lime salts deposited, and even, in time, the formation of little stony masses—**Vein-stones** or **Phleboliths**.

The **Organization** and **Absorption** of a thrombus is a process of some interest. As the coagulum is dead, it is clear that it cannot take part in the process of organization. In studying inflammation this subject will come up for fuller discussion, but it may here be stated that when a piece of dead animal substance is present among the living tissues, the first step towards its absorption is usually its replacement by an elementary tissue, the dead structure constituting, as it were, a mould on which the new tissue forms itself. In the case of the thrombus new-formed tissue springs from the wall of the vessel, and this is accompanied by vessels which sprout from those of the vessel-wall. A vascular tissue thus by slow degrees eats into and replaces the blood-clot. (See Fig. 23.) Through time the calibre of the vessel is occupied by vascular connective tissue as in Fig. 24. This may shrink and obliterate the calibre of the vessel. But sometimes, especially in veins, there occurs a process which is shown in Fig. 24. The contraction of the connective tissue causes widening of the vessels in the new-formed tissue; and there may be produced a tissue with large channels, and through these the circulation and the function of the vein may be restored. A favourite place for the formation of this cavernous tissue is the place of union of the iliac veins to form the vena cava. Here the vessels are sometimes found filled with a spongy tissue through which the circulation is carried on. By a still further contraction of the new-formed tissue, the calibre of the vessel may be

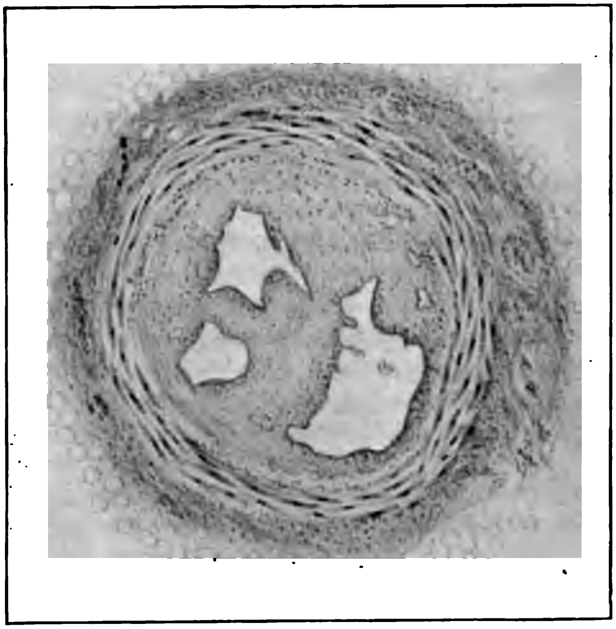

Fig. 24. Vein of leg filled with thrombus, which has become completely organized. New-formed vessels are shown, which have widened greatly so as to partially restore the circulation. ×25.

completely re-established, the sinus-like blood-channels expanding to the calibre of the vessel.

In studying thrombosis, we have left out of account all cases of what is called **septic thrombosis,** where the coagulation arises in connection with the introduction of decomposing material into the veins. Such processes will receive consideration in another part.

Results of thrombosis.—Embolism is a frequent consequence of thrombosis in any situation. (See under Embolism.)

Thrombosis in veins leads most directly to **passive hyperæmia** with its consequent **œdema** and dropsy, and sometimes **hæmorrhage**. The occurrence of serious œdema depends largely on the extent of the anastomosis of the obstructed veins, and also somewhat on the rapidity with which the thrombosis has occurred. If the thrombus forms slowly the functions of the plugged veins may be largely taken up by the lymphatics and by other veins which remain unaffected. In the case already referred to, where a cancerous tumour in the kidney had burst into the renal vein, and thrombosis had extended to the vena cava and down the veins of both legs, there was comparatively little œdema at any time, although all the main venous trunks of both legs were plugged. The fact that the thrombosis does not extend into the capillaries allows the circulation to be carried on by arteries, capillaries, and lymphatics.

At the seat of thrombosis there is usually an **inflammation,** which may be of considerable intensity, and is sometimes accompanied by considerable pain. Even when the thrombus does not include specially irritating material, there is inflammation of the wall, leading, especially in the case of veins, to adhesion to parts around, with induration (*Periphlebitis*). A periphlebitis, accompanied by considerable œdema and by severe pain, occurs in **Phlegmasia alba dolens.**

It is important to know that these secondary effects of thrombosis, and especially œdema, will not usually show themselves for some time **after the onset of the process.** A coagulation beginning in a vein will take some time before it completely obstructs it, and even when it has done so, it may be necessary for it to grow into other veins before any pronounced œdema will develop. Hence it is that a thrombosis may lead to embolism by detachment of portions of the thrombi before it has manifested its presence by hyperæmia and œdema.

Thrombosis in veins seldom leads to **Gangrene,** and in the few cases in which gangrene actually occurs some additional interference with the circulation will usually be discoverable. Weakening of the heart, in conjunction with thrombosis, may cause it, and so may disease of the arteries.

Thrombosis in arteries, occurring, as it does, chiefly along with atheroma, may have as its result ischæmia and its consequences. (See above.)

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II.—EMBOLISM.

Causation.—Any solid material in the circulating blood may obstruct a blood-vessel which it finds too small to give it passage. It may be a foreign body, such as a parasitic animal or vegetable, or a piece of a tissue or tumour or a piece of cretaceous matter broken off from a degenerated valve or vessel. But the most frequent source of embolism is a **pre-existing thrombus**. Thrombi most readily become detached from the heart or veins, and in either case the thrombus is most dangerous when it has grown into the current so as to be exposed to the force of the blood-stream. In a vein a thrombus which completely obstructs the vessel will not be readily carried away. The actual displacement of the thrombus will often take place in consequence of some compression or movement of the body affecting the part where it is seated. This is sometimes seen in the case of thrombosis in the uterine veins where the first considerable movement after delivery may displace the thrombus and lead to embolism in the lungs.

The embolus, whatever its source, will obstruct, for the most part, an artery or capillary. The only practical exception to this is the case of the portal vein, which in its ramifications in the liver has the distribution of an artery. The possibility of a proper venous embolism has been asserted. Foreign bodies, especially if heavy, may fall backwards in the venous system, but this is not an occurrence of any practical moment, if, indeed, it actually occurs in human pathology (Recklinghausen). A thrombus or other loose solid body in the circulating blood will usually in its course be caught at a place where an artery is dividing; it often rides on the bifurcation. It sometimes becomes broken against the projecting bifurcation, and its fragments may be dispersed to the smaller branches, producing numerous emboli in them. The embolus, acting as a foreign body, will usually induce thrombosis on its surface, so that it may get covered in by an **encapsuling thrombus.** As the embolus may be derived from a thrombus, and may induce thrombosis afterwards, it may be difficult to distinguish the one process from the other.

The **Diagnosis of embolism** from thrombosis rests on a survey of the existing conditions. In veins and in the heart any existing coagulum must be a thrombus, as embolism does not occur in them. In arteries we may have either, but the situation and circumstances will often guide us. Thrombosis in arteries almost necessarily implies disease of their walls, and the thrombus is firmly adherent. The embolus, on the other hand, will often be found riding over a bifurcation and non-adherent, or there may be part adherent (the encapsuling thrombus) and part non-adherent. Assistance may often be obtained by finding a source of embolism, such as thrombosis, elsewhere. Again, there are some arteries much more prone to embolism than others. In the arteries of the lungs, intestines, kidneys, and spleen, thrombi are comparatively rare, but in those of the brain, in the coronary arteries of the heart, and in those of the extremities both thrombosis and embolism are common.

Phenomena of embolism.—These phenomena vary greatly in different cases, the variations depending chiefly on the circumstances of the vessels in regard to anastomosing communications. In this respect we have all degrees of difference.

(*a*) **In arteries with free anastomosis.**—In these, embolism will at once cause increase of pressure on the proximal side of the plug, and this, with relaxation of the arteries, may be sufficient to restore the circulation by means of the anastomosing connections. At the seat of the obstruction thrombosis will occur on each side, and by the organization of the thrombus the artery will be permanently converted into a solid cord from the nearest proximal to the nearest distal branch, the circulation being completely carried on by the anastomosing branches. The arteries with freest anastomosis are, in general, those whose branches are most liable from their situations to temporary obstructions from external pressure or otherwise. Hence embolism is usually of trivial consequence in the arteries of muscle, of the skin, of the intestine, of the circle of Willis in the brain (the common carotids are liable to pressure), and of acinous glands. A similar result will follow **capillary embolism.** As the capillaries are in the freest possible inter-communication, embolism produces little disturbance of the circulation, unless, as sometimes happens, there be many obstructed simultaneously.

(*b*) **In arteries with very imperfect anastomosis.**—Cohnheim has endeavoured to distinguish certain arteries of the body as being entirely devoid of anastomosing connections—they are like the branches of a tree, each division having no distal communications with its fellows. Such arteries he calls **End arteries.** It is impossible to carry out this distinction absolutely, inasmuch as nearly all arteries have at least fine communications, and all communicate by their capillaries. It may be said, however, that the following arteries have at least exceedingly imperfect anastomosis, and are practically end arteries, namely, the pulmonary, renal, and splenic arteries, the coronary artery of the heart, the central artery of the retina, and the nutrient arteries of the brain, to which may be added the portal vein. In addition, the superior mesenteric artery and the external iliac arteries have anastomosing communications, which, in relation to the size of these arteries, are small. In such arteries as those mentioned the results of embolism are not strictly uniform, but are nearly always serious. It may be added that the capillaries may to some extent take the place of anastomosing arteries, and the results of obstruction may be thus rendered less serious. Indeed, the area of tissue affected by the conditions to be now described is usually less than that of the distribution of the obstructed artery. The position of the plug is therefore, for the most part, outside the affected area, that is to say, proximal to it.

The phenomena of embolism in the case of end arteries may be included in three processes which manifest themselves separately or in combination, according to the circumstances of the case; these are (1) Engorgement, (2) Hæmorrhage, and (3) Necrosis.

(1) Engorgement is a great distension of the veins and capillaries with blood; in fact, an extreme passive hyperæmia. The mode in which this results from the obstruction of an artery has been well elucidated by the observations of Cohnheim and others. Cohnheim observed the process in the tongue of the frog, where he produced embolism by the introduction of blackened pellets of wax by the aorta. The immediate effect of obstruction of an end artery was usually ischæmia in all the vessels of the part. (See Fig. 25.) Soon, however, a backward flow of blood from the veins was observed, and this produced an engorgement of all the vessels, capillaries, veins, and even the branches of the artery. The explanation of this phenomenon obviously is that, the blood being suddenly deprived of the vis a tergo by the obstruction of the artery, the blood-pressure in all the vessels is reduced

to nil. But the vessels are still in communication with the veins and capillaries around, and so the blood, passing in the direction of least resistance, passes backwards from the veins into the vessels of the part.

(2) Hæmorrhage was, in Cohnheim's observations, seen to follow on the engorgement, and it took place by diapedesis. It is simply an exaggerated form of the hæmorrhage which we have seen to occur in passive hyperæmia, but in this case the nutritive defect in the vessel-walls is a more potent agent.

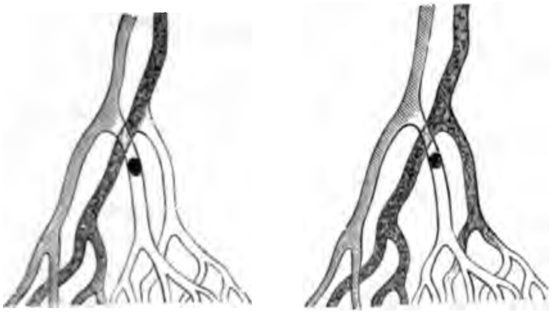

Fig. 25.—Diagram of conditions following embolism of an end artery. In the figure to the left the state of ischæmia immediately after the embolism is shown. In the other figure the regurgitant current from the vein is indicated. (After COHNHEIM.)

The **Hæmorrhagic infarction**, which is most typically seen in the lungs, is the result of the conjunction of the two processes of engorgement and hæmorrhage. Microscopically examined, the blood-vessels are distended with blood, and the lung alveoli are filled with blood to the exclusion of the air. The condition results from embolism of the pulmonary artery, and the piece of tissue involved is wedge-shaped. This piece of tissue is solidified, and presents a deep red colour, as if a solid blood-clot had replaced the lung tissue. (See under Lung.)

Engorgement of the vessels is ascribed by Cohnheim to the regurgitant current from the veins, but further observation has shown that when an artery is obstructed blood flows into the capillaries from all surrounding communications, from arteries and capillaries as well as veins, and the engorgement may be due to the flow from these as much as from the veins. Moreover, the current from the communicating arteries and capillaries may be sufficiently strong to carry on the circulation and prevent any considerable engorgement or diapedesis. This is frequently the case in the lungs, where the hæmorrhagic infarction often fails to develop after embolism. The circulation in the lungs is somewhat special. The capillaries are wide and very abundant, and the bronchial artery not only supplies nutrient branches to the lung tissue but forms anastomosing communications with the pulmonary artery. In consequence there may be none of the phenomena of the hæmorrhagic infarction, and even if the engorgement and hæmorrhage occur, the process usually stops short of an actual necrosis of the tissue. It has been asserted by Grawitz, Hamilton, and others that the hæmorrhagic infarction of the lung is not produced in the way described above, and is not truly embolic in character. The author has, from repeated observations, convinced himself of the embolic character of the condition, and concurs with the view of Cohnheim, recently supported by the further experiments of Orth and Fujinami.

(3) **Necrosis** or death of the tissue sometimes follows on the hæmorrhagic infarction, but it may not so result, and, on the other hand, we often have necrosis without engorgement or hæmorrhage. To allow of the occurrence of engorgement the vessels must remain alive, otherwise the blood will coagulate and obstruct any backward current. But necrosis may occur before time has been given for engorgement, or the engorgement may be limited to the peripheral parts. In the **spleen** and **kidneys** this is frequently the case. The tissue, especially if the artery be of large size, dies without any considerable engorgement, and in these organs the dead tissue undergoes a peculiar process of coagulation (see Coagulation Necrosis), the result being the formation of a dense pale wedge, the **white infarction.** In the spleen and kidney we have all gradations between the white and the hæmorrhagic infarctions, and a white infarction is often surrounded by a red zone in which hæmorrhage has occurred. In the **brain** and **retina** necrosis occurs in the form not of coagulation but of softening, and there is usually little hæmorrhage, hence a white softening.

The **superior mesenteric artery**, although it has many anastomosing branches, is so large in comparison with these vessels that its obstruction may lead to engorgement and necrosis in the portion of intestine to which it is distributed.

The **portal vein** is in its distribution an end artery, but infarction does not occur as a result of plugging. The explanation is that, not only is the liver supplied by the hepatic artery in addition to the portal vein, but the blood of the former, after passing through its own proper capillaries in the walls of the vessels and connective tissue of the liver, is carried into the interlobular veins which are the terminals of the portal vein. Obstruction of the latter will not therefore stop the circulation.

It will be obvious that **arteries possessing free anastomoses may be reduced to the condition of end arteries** if their anastomoses are no longer available. If, as sometimes happens, an embolus passing to the leg breaks up, say, by being propelled against a bifurcation, and is scattered to a number of stems simultaneously, then the circulation will be re-established very slowly or not at all, and necrosis is liable to occur, especially if the circulation is already feeble. Thus, we may have gangrene of the toes occurring in this way. It is to be added that, in old people, obstruction of a number of arteries sometimes occurs from thrombosis as a result of atheroma, and this may likewise lead to necrosis.

Disposal of the infarction.—In the case of the hæmorrhagic infarction of the lung, if necrosis does not occur there may be complete restoration. The circulation may be resumed by organization and vascularization of the plug in the manner already described under Thrombosis, and the blood being removed from the alveoli, the air re-enters. (For proof of this see under Lung, Hæmorrhagic Infarction.) In some cases, however, necrosis does occur, so that, if the patient survive, symptoms like those of phthisis develop, and lung tissue has been known to be spit up. As the necrosed lung tissue is disposed of a cicatrix will take its place.

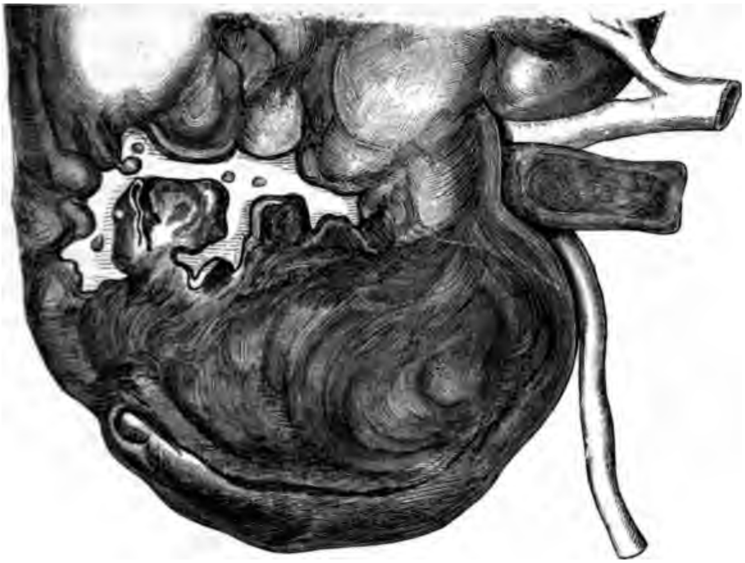

Fig. 26.—Infarction of kidney undergoing absorption. The infarction is white and depressed below the level while the tissue is puckered around it. (After Rayer.)

The solid infarctions in the spleen and kidneys, whether red or white, are treated like dead animal matter in any protected situation among the living tissues. They are gradually absorbed (see Fig. 26) and their place is taken by cicatrices, in the midst of which, even at a late date, little pieces of cheesy-looking material may be seen. In the case of red infarctions, the blood-pigment is first dissolved out of the corpuscles, and then partly absorbed and partly deposited in the form of solid granules, the result being that the infarction becomes pale.

The softened brain tissue is also absorbed, and a cicatrix or a cyst takes its place. So is it with the retina, the piece of tissue is lost and absorbed. In the case of the superior mesenteric artery, the slough of the bowel and hæmorrhage lead on mostly to a fatal result, but cases do occur in which, after the separation of a slough, an ulcer is left which may ultimately cicatrize.

Special forms of embolism.—(1) **Malignant tumours** not infrequently extend into the blood and form secondary tumours by embolism. (See Metastasis of tumours.)

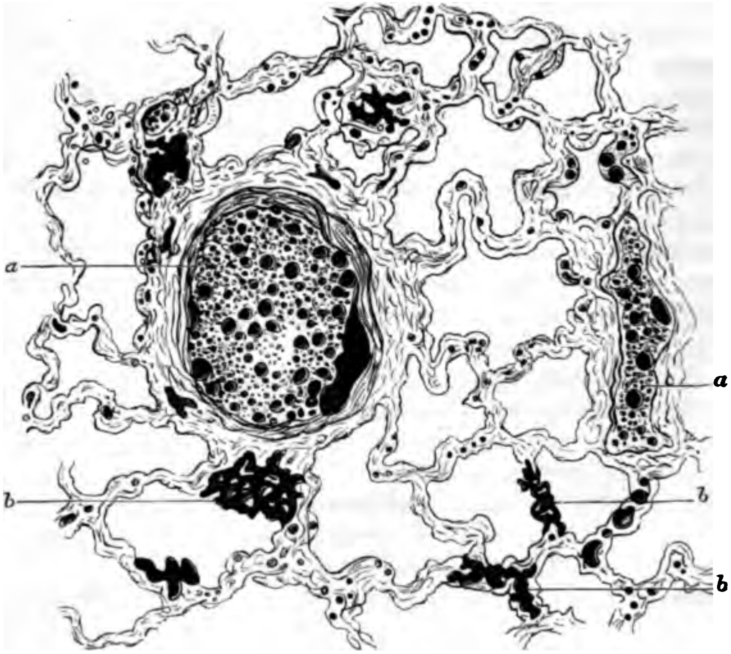

FIG. 27.—Fat in pulmonary vessels in lipæmia producing embolism chiefly of the capillaries. (SAUNDERS and HAMILTON.)

(2) **Parenchymatous cells.**—In certain injuries and affections of bone, cells with all the characters of bone-marrow cells have been found in the pulmonary capillaries. Instances of emboli consisting of liver, spleen, and placental cells are also known.

(3) **Fat-embolism.**—Oil or fluid fat not infrequently gets into the blood, and it may obstruct the small arteries and capillaries (see Fig. 27). This occurs mostly in consequence of fracture of bones, but also after injuries to the subcutaneous adipose tissue, as in operations, or from rupture of the liver when it contains fat in excess. In these cases the fat finds entrance to the blood by the veins which are ruptured, but there are cases in which apparently it reaches the blood circuitously by the lymphatics; in suppurations occurring in parts

rich in fat, such as the uterus after delivery (endometritis), this may occur (Cohnheim). Oil also occurs in the blood in cases of diabetes. (See Lipæmia).

The oil finds its way, carried by the blood, to the right side of the heart and on into the lungs. If small in quantity it obstructs a few capillaries and small arteries, and there is no appreciable result. But if a considerable number of small arteries near each other be obstructed, or even a large number of capillaries, we may have a condition resembling the hæmorrhagic infarction. In some cases the oil may, to some extent, pass through the lung capillaries, and it is then found mostly in the Malpighian tufts of the kidney, one or two loops being here and there filled. There are a few rare cases on record in which extensive embolism has occurred in the smallest vessels of the brain, conjunctiva, skin, muscles, heart, intestines, liver, and kidneys, and has apparently been the cause of death.

The oil may be detected in the capillaries or small arteries in the lung or elsewhere, especially in sections which have been treated with osmic acid.

(4) **Air-embolism.**—The admission of a considerable quantity of air into veins near the heart often leads to a fatal result, and some have supposed that embolism in the lungs is the cause. As the pressure in the veins near the heart is very low, and there is even a degree of suction during inspiration, there is great danger in opening such a vein as the jugular. Air admitted at a distance from the heart, as by the uterine veins after delivery, may also cause death (Birch-Hirschfeld). In regard to the cause of death in these cases it is important to notice that a repeated admission of small quantities of air does not produce serious results, whereas a single large admission is rapidly fatal. This hardly looks as if embolism were the cause, and, as a matter of fact, the air is found after death mainly churned up with the blood in the right auricle and ventricle, which are usually enormously dilated. It seems that the right ventricle, in contracting, merely squeezes together the elastic air which again expands during the diastole. The force of the heart is thus fruitlessly expended and the blood is not sent into the pulmonary artery. Moreover, the over-distension of the right auricle with air prevents the admission of blood from the venæ cavæ. Thus the circulation is at a standstill and death results. This explanation is not universally accepted.

(5) **Infective embolism.**—Hitherto the phenomena of embolism have been referred to on the supposition that the obstructing plug is in itself of an indifferent nature. If this is not so, and especially if the plug contains specific microbes, more particularly those of inflammation

(pyogenic), then the results are very different. In some cases the veins are in communication with wounds which are the seat of decomposition, and the thrombi which form contain pyogenic microbes. If embolism occurs, then each embolus, whether in an artery or capillary, is likely to form a centre of inflammation. Hence arise multiple abscesses, chiefly in the lungs, but also in the kidneys, liver, and elsewhere. A similar infective embolism may occur in consequence of the existence of a focus of infection in the heart. (See Ulcerative Endocarditis.)

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HÆMORRHAGE.

Two forms of hæmorrhage are to be distinguished, namely, by rupture (*per rhexin*), and by diapedesis (*per diapedesin*). In the latter case the blood escapes through the walls without solution of their continuity. Hæmorrhage by rupture may take place from any size or kind of vessel, and when it occurs there will be an escape of the whole blood. Hæmorrhage by diapedesis occurs only in the finest vessels, mainly the capillaries; it is chiefly the red corpuscles which escape, and with them, of course, some fluid, but the fluid has not the constitution of the entire blood plasma.

1. **Causation.**—The escape of blood is produced for the most part by injury or disease of the walls of the heart or blood-vessels, or by an increase in the blood-pressure, or by both combined. Some would add to these, alteration in the constitution of the blood, but this will act in most cases by injuring the walls of the vessels. It is not possible to separate accurately in their causation hæmorrhage by rupture and by

diapedesis. It will be more useful to enumerate the various conditions which may lead in one way or other to hæmorrhage.

Hæmorrhage is most simply produced by **Direct injury** (traumatic hæmorrhage), as in wounds, bruises, fracture of bones, etc. It may be produced by **Reduction of pressure outside** the vessels, so that the blood-pressure is relatively increased. In this way we may have hæmorrhage as a result of reduction of the atmospheric pressure in cupping, in ascending hills, or in balloons. To a similar cause may be ascribed hæmorrhage on sudden removal of tumours or exudations.

Venous obstruction is one of the most important causes of hæmorrhage. A frequent example of this is afforded by hæmorrhage from the stomach and intestine in consequence of obstruction of the portal vein by thrombosis or by cirrhosis of the liver. Thrombosis of the longitudinal sinus of the dura mater may lead to hæmorrhage into the brain substance; the hæmorrhage is usually capillary, but may be in the form of a large extravasation. Violent contraction of muscles is not a common cause, but in severe vomiting the obstruction of the veins by the contraction of the muscular coat of the stomach frequently produces ecchymosis of the mucous membrane and erosions, and sometimes leads to considerable hæmorrhage. In all these cases the venous obstruction induces passive hyperæmia, and the hæmorrhage is mostly by diapedesis.

Increase of arterial pressure is rarely in itself a cause of hæmorrhage. It is probably the chief element in the causation of the small subpleural and subpericardial hæmorrhages met with in death by asphyxia. (See under Organs of Respiration.) It is, on the other hand, a frequent contributing cause where there is existing disease of the vessels.

Disease of the walls of the heart or vessels is another cause of hæmorrhage. In this category are included conditions of the heart due to disease of the coronary arteries (which see), aneurysm and atheroma of arteries, and varicose dilatation of veins. In all of these a rise in the blood-pressure is frequently the determining cause of the hæmorrhage, and hypertrophy of the left ventricle, implying a more or less permanent elevation of the blood-pressure, forms a constant source of danger, where the vessels are diseased. New-formed vessels whether in inflammatory new-formations or in tumours, are prone to rupture, presumably on account of thinness of their walls. **Obstruction of arteries and capillaries** produces hæmorrhage, as we have already seen, in the case of the hæmorrhagic infarction. Fat-embolism, even when the obstruction is entirely capillary, may have this effect, and according to Busch and Recklinghausen the hæmorrhages may be in the brain and heart as well as in the lungs.

Hæmophilia or **Hæmorrhagic diathesis** is a condition in which hæmorrhage is apt to occur from very trivial causes, and it is very difficult to get the hæmorrhage stopped. It is an eminently hereditary condition, and is probably due to faulty construction of the vessels. Virchow has observed thinness and smallness of the aorta in one case, and Blagden describes a case in which the arteries were thin and nearly transparent.

Blagden's description of the whole case certainly suggests defects in the arteries as the cause of the hæmorrhage. The patient, when a boy, had a tooth extracted, and the bleeding lasted 21 days. At the age of 26 a slight wound of the forehead caused a long-continued and recurring hæmorrhage. The divided vessel was ligatured in two places, but it gave way behind the ligature, and the hæmorrhage returned. The coats of the vessel were observed to be very thin, like paper. This hæmorrhage was ultimately stopped by the application of caustic potash, which caused extensive sloughing and exfoliation of bone. The fatal hæmorrhage resulted from the extraction of a tooth. There was profuse bleeding from the alveolus, which could not be controlled by stuffing the socket, by cold, or by the cautery. Then the carotid was ligatured, but the bleeding continued, and occurred also in the operation wound. The patient died a week after the extraction of the tooth. After death the coats of the temporal and some other branches of the external carotid were seen to be thin and nearly transparent.

Alteration of the blood is another cause of hæmorrhage. It may be that the blood has been altered as regards one or more of its essential constituents, as in scurvy, anæmia, leukæmia, or that a morbid poison is present in the blood, as in typhus fever (petechiæ in skin), small-pox, yellow fever, snake-bite, poisoning by phosphorus. Watson Cheyne and Russell have ascribed the hæmorrhage in **purpura** to obstruction of capillaries by colonies of microbes. Weigert has described a similar condition in hæmorrhagic small-pox.

Nervous influences may lead to hæmorrhage. The physiological hæmorrhage of menstruation is effected by means of the nervous system. The same applies to **vicarious menstruation**, in which, in consequence of interference with the ordinary process in the uterus hæmorrhage occurs in other situations, as the nose, mouth, or lungs. **Bloody-sweating** or Hæmatidrosis is another instance of bleeding in consequence of nervous influences.

2. **Stilling of hæmorrhage.**—In the case of hæmorrhage by diapedesis, and more particularly in hæmorrhage due to passive hyperæmia and alterations in the blood, the hæmorrhage will cease when the cause is removed. If the vessel has been actually ruptured, then **the stoppage will occur by thrombosis.** The torn edge of the aper-

ture will itself induce thrombosis (Fig. 21, page 81), and as the blood is in motion the thrombosis will be a white or mixed one. It often happens that as the current is too strong to allow of a thrombus readily forming at the aperture, the coagulation may begin in the blood outside, and the clot thus formed may materially assist in stopping the aperture. Thus in the case of a divided artery the contraction of the muscular coat causes narrowing of the calibre and a withdrawal of the vessel within its sheath. There is thus left a certain extent of empty sheath in which the blood may coagulate. This contraction of the muscular coat is brought about in the first instance by the stimulus of the agent which caused the rupture, and it will be kept up by the irritation of the blood on the exposed and torn structures. Other circumstances may favour the stilling of the hæmorrhage. If the bleeding is considerable the anæmia, by weakening the heart and reducing the blood-pressure, will more readily allow of thrombosis. On the other hand, circumstances may be unfavourable to the stilling of the hæmorrhage, more especially when they hinder contraction of arteries. Amongst these may be mentioned disease of the walls of arteries (atheroma, aneurysm), the application of warmth, and a longitudinal wound. In the last-mentioned case the contraction of the artery will cause the wound to gape, and the hæmorrhage is with difficulty stopped unless the surgeon cuts the vessel right across.

3. **Seat of the effused blood.**—When bleeding occurs at the free surface of the body, the blood usually passes away and is lost. On the other hand, it may take place into an existing cavity, or the blood may make a cavity for itself by tearing. Sometimes the blood in such a cavity forms a distinct tumour-like mass, which may be somewhat permanent ; this condition is called **Hæmatoma.** If the blood permeates the interstices of the tissues without tearing, the condition is called **Hæmorrhagic infiltration.** Infiltration of the skin or subcutaneous tissue is called **Ecchymosis** or **Sugillation.** Small patches of hæmorrhage in the skin arising chiefly in purpura and acute fevers are called **Petechiæ** or **Vibices.**

Certain hæmorrhages have received special names; thus, **Epistaxis** is bleeding from the nose, **Hæmatemesis** from the stomach, **Hæmoptysis** from the respiratory organs, **Metrorrhagia** from the uterus, **Hæmaturia** from the urinary organs. When blood accumulates in cavities, special names are sometimes given; thus in the case of the uterus, **Hæmatometra**; of the pleura, **Hæmothorax**; of the pericardium, **Hæmopericardium**; of the tunica vaginalis of the testicle, **Hæmatocele.**

4. **Disposal of the blood.**—In the case of hæmorrhage by diapedesis and in most hæmorrhagic infiltrations, the blood, being in the serous

spaces and in communication with the lymphatics, is readily carried off. Before it is finally disposed of in this way, however, it may have undergone changes, especially in the red corpuscles, such as result in a greater or lesser degree of pigmentation. These changes are, however, similar to those about to be mentioned as occurring in larger hæmorrhages.

In larger hæmorrhages the blood forms a mass and coagulates, while at the periphery there is a certain amount of infiltration into the surrounding tissue. An early phenomenon is the solution of the hæmoglobin of the red corpuscles. A red solution is thus formed which may stain the tissues for some distance around. The peculiar bright red colour which one sees in the neighbourhood of a hæmorrhage in the brain, or the various colours seen in the skin after an effusion of blood into it, are due to staining of the tissues with the dissolved colouring matter of the blood, but neither of these is permanent. As the pigment is dissolved it will pass off with the fluid into the lymphatics, and the staining, while it may be somewhat extensive, will be evanescent.

A more durable **Pigmentation** may result in two different ways. In the first place, the colouring matter after being dissolved out of the corpuscles is often, after a time, deposited in the solid form, appearing as crystals of hæmatoidin (see Fig. 28), or as granules. This solid pigment is somewhat permanent. In the second place, the red blood-corpuscles may be taken into the substance of other cells, and so disposed of. (See Pathological Pigmentation.)

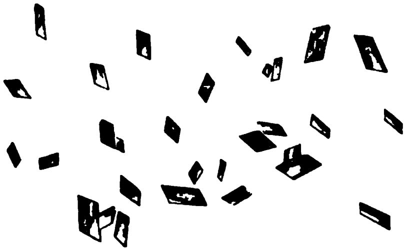

Fig. 28.—Crystals of hæmatoidin from an old hæmorrhage in the brain. Their colour is reddish brown. ×350.

If the blood is considerable in amount it comes to be treated as a piece of dead animal matter in the midst of the living tissues. Inflammation occurs around it, and this leads to what is called **Organization of the clot.** In this case the process is very similar to that already referred to in the organization of the thrombus (which see), and the result is usually the formation of a cicatrix. Sometimes a process in some respects similar to the formation of cavernous tissue in place of the thrombus occurs, but instead of the meshes being filled with blood they are filled with serous fluid. Thus in the case of a hæmorrhage in the substance of the brain the new-formed connective tissue which replaces the effused blood is unable from the brittle nature of the brain tissue, and from the fact that it is contained in a closed rigid cavity, to form a cicatrix by its contraction. Instead of that, by its contraction it leaves spaces which are filled with serous fluid, and so we have the **apoplectic cyst.**

An old clot which is not in a position to be readily disposed of in any of the ways described may dry in and finally become impregnated with lime salts. It need hardly be said that when exposed to septic influences a clot is liable—perhaps very liable—to undergo decomposition.

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ŒDEMA AND DROPSY.

In order to understand these conditions it is necessary to refer to certain points in the normal relations of **the lymphatic circulation.** The connective tissue throughout the body is as it were permeated with spaces of various shapes in which the connective tissue corpuscles lie. These lacunæ or **serous spaces** are lined with endothelium like the blood-vessels and lymphatics themselves. The serous spaces are provided (as shown in Fig. 29) with numerous anastomosing processes, and they communicate on the one hand with the interior of the blood-vessels, and on the other with the lymphatics. Arnold and others (see Fig. 30) have succeeded in injecting the serous spaces from the blood-vessels, especially when, as in passive hyperæmia, the channels of communication between blood-vessels and spaces have been widened. A circulation of a clear fluid—the *lymph*—is continually proceeding from the capillary blood-vessels into these spaces, and so into the capillary lymphatics. The escape of fluid is brought about by means of a process of filtration and a process of diffusion or osmosis. Heidenhain and others attribute to the endothelium of the capillaries a certain secretory function, and thus account for the variation in the composition of the fluid in different parts of the body. This view, however, is not universally accepted. The **serous cavities** of the body are to be regarded as large serous spaces. They also are lined with endothelium, and are continuous with the lymphatic capillaries. To a considerable extent also the lung alveoli are similar to the serous spaces. We know that fine dust inhaled into the alveoli readily passes into the lymphatics, and in œdema of the lung the fluid is in the alveoli.

Œdema is overfilling of the serous spaces with fluid, **dropsy** is overfilling of the serous cavities, but the latter term is often used in a general sense to include both. When œdema affects the body generally it is often called general dropsy, or **Anasarca** or **Hyposarca**. Opposed to this are local œdema and local dropsy. Special terms are in use according to the locality of the fluid accumulation. When present in the abdominal cavity the term **Ascites** is used, when in the pleural and pericardial sacs the terms **Hydrothorax** and **Hydropericardium** are employed. **Internal** and **External hydrocephalus** signify fluid accumulations in the ventricles and in the soft membranes of the brain respectively.

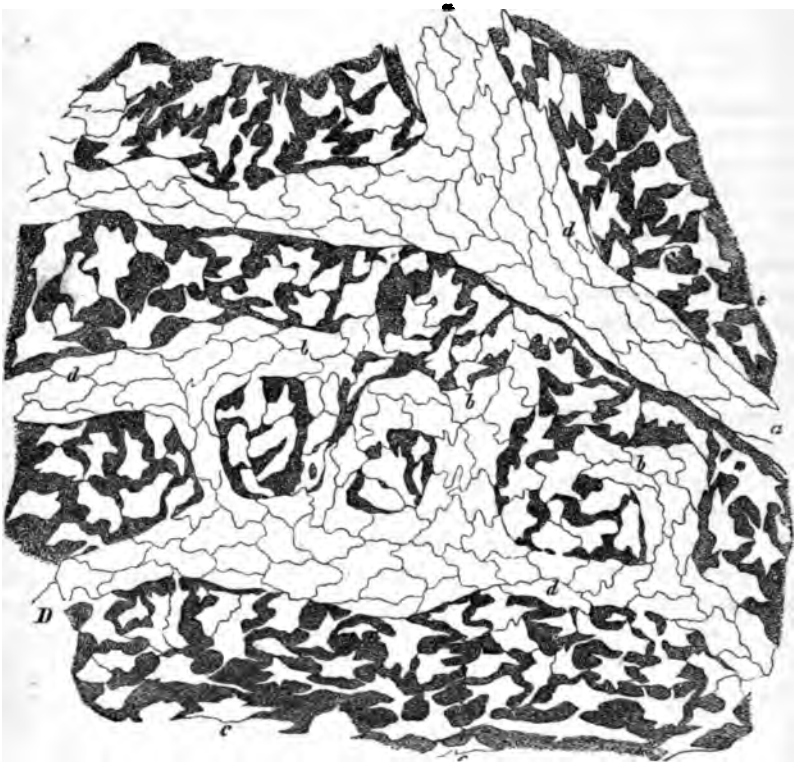

Fig. 29.—Serous spaces (*c*, *c*) and lymphatic capillaries (*d*, *d*) on pleural surface of diaphragm in preparation treated with nitrate of silver. The connection of the branched spaces with the commencing lymphatic vessels is shown. (RECKLINGHAUSEN.)

Causation and nature of the process.—Anything which causes an excess of fluid in these spaces or cavities will produce œdema or dropsy, and the first condition which suggests itself is obstruction of the lymphatics. The force which carries on the lymphatic circulation is largely the blood-pressure propagated from the capillaries, and it may be expected that **obstruction to a lymphatic stem** would produce accumulation of fluid in the spaces. But it is to be remembered that the serous spaces are in as close relation to the blood-capillaries as they are to the lymph-capillaries, and any obstruction to the lymphatics will probably have the effect of causing the transuded fluid to return to the blood-capillaries. Majendie demonstrated that the power of absorption possessed by the veins is very great, and experiment has shown that the whole lymphatics of a limb may be ligatured, or what is equal to that, the entire lymphatic glands excised without producing œdema. The blood-vessels take up the functions till new lymphatic channels are formed.

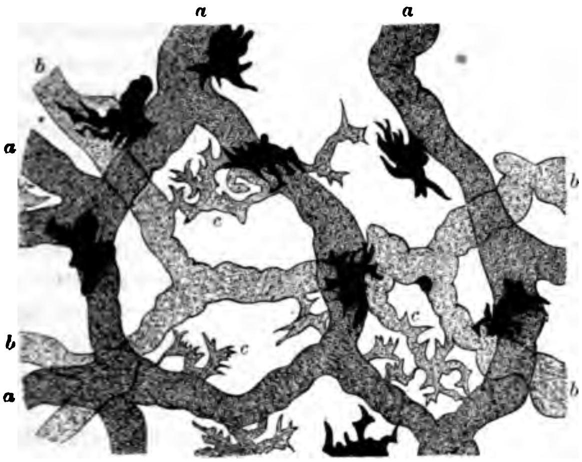

Fig. 30.—Capillary blood-vessels, serous spaces, and capillary lymphatics of the frog's swimming web, filled with (blue) injection material thrown into the blood-vessels. (The black branched bodies are the normal pigment cells.) *a*, *a*, Capillary blood-vessels filled with injection material. *b*, *b*, Lymphatic capillaries also injected but less full than the blood capillaries. *c*, *c*, Serous spaces injected from the blood-vessels. The injection was made after passive hyperæmia had been produced by ligaturing the vein. (ARNOLD.) ×250.

When the **Thoracic duct** is obstructed there is not necessarily any œdema or dropsy, although lesions which obstruct the duct generally interfere also with the veins and predispose to œdema. On the other hand, when the duct is obstructed there is distension distal to the seat of obstruction, and this may lead to **rupture** of the chyle vessels in the abdomen or of the duct itself. In this way occur **Chylous ascites** and **Chylous pleural exudation.** Recklinghausen has also seen a case of chylous ascites arising from obstruction of the chyle vessels of the mesentery with cancerous growth. Manson, again, accounts for the occurrence of chylous urine and lymph scrotum by obstruction of the lymphatic glands with the embryoes of the filaria sanguinis (see under Parasites). We may say, however, that with these exceptions, obstruction of lymphatics does not of itself lead to œdema or dropsy, although it is clear that it may aggravate an œdema whose cause is to be found in some other condition.

The most frequent cause of œdema and dropsy is **Passive hyperæmia,** such as results in cases of uncompensated valvular disease of the heart, cardiac insufficiency, or marked pulmonary obstruction. Here there is increased pressure in the capillaries and veins, and a greatly increased transudation. From what has gone before, it will appear probable that the increase of pressure is not the only element in the case, but that the capillary wall is so altered as to be abnormally permeable. Indeed, alteration of the capillary wall is evidently the more important, as shown by the fact, already referred to, that œdema is most likely to occur where from weakness of the heart the circulation is specially sluggish. It is so, for example, in hypostatic hyperæmia. The observations of Lazarus-Barlow indicate that increase of venous or of lymphatic pressure alone is insufficient to produce œdema, and that in the œdema of passive hyperæmia insufficiency in the supply of blood or in the quality of the blood is the essential element. This view appears more probable when we find that **Active hyperæmia** rarely produces œdema unless complicated with inflammation, in which case the agent which causes the inflammation presumably acts on the capillary wall. (See under Inflammation.) In passive hyperæmia the fluid exuded is a watery serum, and as there is diapedesis it contains red corpuscles in considerable numbers. The red corpuscles are taken up by the leucocytes, and carried to the lymphatic glands where they disintegrate.

It should be added that in the case of passive hyperæmia it requires considerable increase of pressure in the capillaries to produce an œdema. It has even been stated that a simple passive hyperæmia, apart from vaso-motor paralysis (producing also active hyperæmia), does not lead to œdema. It has been shown that if the iliac vein of a dog be ligatured there is no œdema till the sciatic nerve is cut. The explanation of this, however, may be that on account of its anastomoses the obstruction of this vein does not raise the blood-pressure sufficiently to induce œdema, whereas a coincident vaso-motor paralysis producing dilatation of the arteries raises the blood-pressure sufficiently. Experiment proves that if a sufficient number of veins be obstructed œdema will result without vaso-motor paralysis. Sotnitchewsky, by introducing plaster of Paris into a peripheral vein of the leg of a dog while the thigh was constricted by an elastic band, succeeded in obstructing a number of veins by the gypsum hardening in them. In this case œdema followed without the induction of vaso-motor paralysis. In passive hyper-

æmia from thrombosis of veins there are usually many veins obstructed before œdema occurs. In the case of passive hyperæmia from heart-disease it may well be supposed that the prolonged venous engorgement will produce an extensive deterioration of the capillary wall, besides a deterioration of the blood itself. Hence valvular disease of the heart is the most frequent cause of this form of œdema.

A watery state of the blood, or **Hydræmia**, is frequently asserted as a cause of the so-called **cachectic œdemas**. According to Cohnheim and his assistants a simple anæmia induced in animals by repeated blood-lettings and the replacement of the blood by a solution of common salt, is not sufficient to induce œdema. In the human subject, however, the conditions are different from those of such an acute hydræmia, in respect that in chronic emaciating diseases we have a prolonged deterioration of the blood, during which the general nutrition of the tissues suffers. Under these circumstances the blood-vessels become more permeable. There is usually also in these diseases weakness of the heart, and consequently a tendency to passive hyperæmia in dependent parts. A slight amount of passive hyperæmia will, in the existing state of the blood and tissues, induce œdema. In accordance with these facts, the œdema is usually in the lower extremities.

Thoma has pointed out that sclerotic vessels are much more permeable to fluids than healthy vessels, and he inclines to regard the majority of the so-called hydræmic or cachectic œdemas as instances of what he designates **Angio-sclerotic œdema.**

The toxic products of bacteria circulating in the blood are believed by Hamburger to produce œdema, either by causing undue permeability of the capillary wall, or by a stimulant action on the endothelium of the capillaries. He holds that alterations in the composition of the blood in such diseases as nephritis may act similarly.

The causation of the characteristic **Œdema of Acute Bright's disease** is much more difficult to explain. There is, indeed, in this disease a serious reduction in the specific gravity of the blood serum. It has been found reduced to 1020, or even 1013, instead of standing at 1030, which is the normal. This hydræmia is induced in two different ways. There is the loss of albumen, which renders the blood directly more watery, but there is also an abnormal retention of the water in the blood, as there is a great reduction in the amount of urine secreted. These facts naturally suggest that if the œdema in Bright's disease is not due simply to the hydræmia, it may be due to this in conjunction with the increased bulk of the blood, to a **Hydræmic plethora**. This view has obtained much support. It has been supposed that, the entire bulk of the blood being increased, there will be increased pressure in the capillaries and increased transudation from the watery blood. This explanation, however, is not a sufficient one, as it is opposed by observations in the human subject and by experiments on animals. In the first place there are cases of absolute suppression of urine, as in hysterical females, etc., in which we must presume an exaggerated hydræmic plethora, but without a trace of œdema, and, in the second place, an exaggerated hydræmic plethora may be induced in animals without leading to œdema of the skin.

In some experiments by Cohnheim and Lichtheim, a hydræmic plethora was induced by injecting a solution of common salt into the vessels of animals. Enormous quantities, in some cases more than three times the bulk of the blood, could be injected without killing the animal. As in other cases of transfusion, these injections did not produce any permanent rise in the blood-pressure. The most direct result was a great acceleration in the speed of the blood-current, presumably from the diminished friction of the watery blood. There was also a greatly increased transudation, and consequently, increased flow of lymph. But this was remarkably localized. There was a greatly increased flow of lymph in the thoracic duct, showing that in the viscera the transudation was increased; while the lymphatics of the limbs showed no increase, indicating that in the skin and muscles the transudation was not increased. There was also greatly increased secretion from the salivary glands, stomach and intestine, liver, lachrymal glands, and kidneys. In these organs an œdema was developed, that is to say, in the mucous membrane and submucous tissue of the stomach and intestines, in the lymphatic glands of the mesentery, in the pancreas, kidneys, gall bladder, salivary glands; there was also ascites, but no œdema of the subcutaneous tissue. The explanation suggested for this localization of the increased transudation and the œdema is, that these organs are all normally concerned in the removal of water from the blood, and that probably their blood-vessels are unusually permeable to water. The experiments produce a great increase in the water of the blood, and the vessels give ready passage to it.

These observations and experiments may seem to throw little light on the œdema of Bright's disease, except in a negative way. But looking closely at the experiments, they show that hydræmic plethora induces increased transudation and œdema in parts predisposed. In Bright's disease we have two elements which are wanting in these experiments. On the one hand the kidneys are inactive, and on the other there is in the blood an irritant, which, acting on the kidneys, has induced the disease in them. This irritant may be presumed to act on the skin as well as on the kidneys. As Cohnheim has pointed out, there are many facts which indicate a close relation between the skin and kidneys in Bright's disease. In scarlatina, for instance, we have an acute inflammatory hyperæmia of the skin during the febrile stage. But there are, even in this stage, inflammatory changes in the kidneys, and when these phenomena advance sufficiently to induce a hydræmic plethora, it is perhaps not remarkable that œdema occurs in the previously damaged skin. In the experiments above referred to, it was found that although the normal skin did not become œdematous, yet when it had been previously inflamed, as by pencilling with iodine solution, or by exposing to a strong sun, then œdema showed itself. The œdema of Bright's disease hence approaches in its pathology to **inflammatory œdema.**

Nervous influences sometimes play a part in the production of œdema. The most familiar examples of this are afforded by erythema nodosum, and urticaria, where nervous irritation, usually reflex, induces localized swellings, presumably œdematous, in the skin. The bites of insects, especially fleas, produce similar effects in some persons, and in this case as in the others, there are sensations indicating irritation of the nerves. In injuries to nerve-stems, some authors have observed local œdema, and œdema sometimes follows paralysis, both paraplegic and hemiplegic, in the latter case forming a **hemi-anasarca.** Probably in all these cases the nervous lesion merely induces a condition of the vessels which predisposes to œdema, and its actual occurrence is determined by other causes. Thus in the case of flea bites, the parts are usually subjected to rubbing, while in paralysis the position of the limbs, conspiring with vaso-motor paralysis, may determine œdema by inducing passive hyperæmia.

Position and character of the transudation.—The fluid transuded accumulates where there is room for it, and especially in places where the tissue is loose and easily stretched. The elasticity of the tissue will therefore have a considerable influence on the locality of the œdema. The œdema of Bright's disease, for instance, frequently begins in the loose subcutaneous tissue about the eyelids, and œdema in the larynx is in the loose ary-epiglottic folds.

The dropsical fluids are deficient in albumen as compared with the liquor sanguinis or inflammatory exudations, but they contain soluble salts in proportions nearly equal to these fluids.

The amount of albumen varies in different cases, being determined to some extent by the state of the blood, and the condition of the blood-pressure. It varies also very markedly according to locality. Thus the percentage of albumen is stated by Reuss to be, in the case of the pleura, 22·51; pericardium, 18·33; peritoneum, 11·14; subcutaneous tissue, 5·79; brain and cord, 1·14. Recklinghausen accounts for the larger amount of albumen in the pleura and peritoneum, as compared with the subcutaneous tissue and pia mater, by the greater richness of the former in capillaries. Some authors assert that in the pia mater there are only veins and arteries. The fluid according to its circumstances may contain bile pigment, biliary acids, fat, etc., and in Bright's disease it regularly contains urea.

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SECTION IV.

INFLAMMATION.

Etiology. Produced by "irritants," whose character is to injure the tissues; influences of nervous system, etc.; mode of entrance of irritants. I. **Principal phenomena**, exhibited in an experiment. II. **The state of the vessels**, (Contraction not essential) dilatation with active hyperæmia, followed by retardation; explanation of these; pavementing of veins. Increase of temperature, not due to heat production, but to excess of blood. III. **The inflammatory exudation**. (1) The serous and (2) the fibrinous exudation, (3) exudation of white corpuscles by emigration and of red by diapedesis, explanation of these; chemiotaxis; phagocytosis, (4) cells from other sources, (5) the purulent exudation, suppuration due to pyogenic microbes; the abscess; (croupous and diphtheritic exudations). IV. **Changes in the tissues**. (1) Parenchymatous changes; (2) New-formation of tissue, (*a*) in the granulating wound; the formative cells and their origin; new-formation of blood-vessels and of epithelium; (*b*) other inflammatory new-formations. V. **The issues of inflammation**. VI. **Systemic changes resulting from inflammation**. VII. **Terminology of inflammation**.

THIS is a subject whose importance in pathology can hardly be overestimated. From the time of John Hunter its phenomena have been taken as the basis of various speculations on the nature of pathological phenomena in general. Within recent times the whole subject has become so complex and many-sided, owing mainly to the various limitations and extensions of the term Inflammation, that the question of entirely deleting the time-honoured name has been seriously discussed. It is quite probable, indeed, that fuller and maturer knowledge may render this expedient in the future. Despite the numerous and searching investigations into the nature and meaning of the complicated problem, it is still quite impossible to give a strictly accurate and all-embracive *definition* of Inflammation. In the various organs of the body we meet with it under different aspects. In the skin and other exposed parts, it is manifest by the four so-called cardinal signs or symptoms—redness, swelling, heat, and pain (*rubor*, *tumor*, *calor*, *dolor*), to which is usually appended altered function—(*functio læsa*), and the oldest and certainly the simplest definition of inflammation distinguishes it as a condition characterized by these. But these signs by no means apply universally, and they are typical rather of the early stages than of the later ones. Perhaps a definition which takes cognizance of the etiological character is least open to objection, and from this point of view inflammation may be defined as the reaction of the tissues to an injury sufficient to damage them.

ETIOLOGY OF INFLAMMATION.

As we shall see later the term reaction may be limited or may be used in an unrestricted sense to include a number of different vital processes, circulatory disturbances, retrogressive and progressive changes, the intention of which is adaptive, protective, and reparative.

For the present we shall consider the earlier manifestations of this reaction to injury. By the application of a powerful acid or other caustic to the skin or mucous membrane, the part with which the caustic comes into contact is killed outright, but around this part dilatation of the vessels and certain other phenomena, to be presently described, occur, which constitute what is called inflammation. If the irritation be less intense, if the acid or other caustic be dilute, no certain death of any part may occur, but the tissues with which the substance comes into contact are sufficiently damaged to give rise to a reaction on the part of the tissues, and this is usually sufficiently marked to constitute inflammation. With a very dilute caustic the irritation produced may be so slight as simply to lead to dilatation of the vessels and practically nothing more. This is not inflammation, it is simple congestion, but the boundary line between the two cannot be sharply drawn.

In inflammations of internal organs it often happens that no definite cause is to be discovered, but even in them the direct action of an irritant is sometimes demonstrated. The inhalation of irritant vapours will produce inflammation of the trachea and bronchi and even pneumonia, and the administration by the mouth of turpentine, copaiba, and other drugs, will lead, after absorption into the blood, to irritation and inflammation of the kidney. So also the application of large blisters, especially in debilitated subjects, may lead to the same result through absorption of cantharidin into the circulation. The injection of arsenical and mercurial solutions into the blood-vessels will produce among other results inflammation of the intestinal tract. And so it is probable that in all inflammations we are to infer the existence of some deleterious agent, although it is very often difficult to tell whence it has come and what is its nature.

At this point it may properly be inquired whether the **Nervous system** has anything to do with the causation of inflammation. There are not a few facts which suggest, at least, some connection. In some of the instances the connection is clearly an indirect one. For instance, when inflammation of the eye results from division of the fifth nerve, the inflammation is really traumatic in origin. By the severance of the nerve the reflex action of winking is abolished as well as the secretion of tears, and so the organ is exposed to injuries and unable to get rid of foreign bodies. The inflammation is clearly the result of irritation from without, for, if the eye be carefully protected the inflammation does not occur. Similarly, on account of the diminished resistance offered to injuries, anæsthetic parts in general are specially liable to inflammation, and the inflammation is apt to be exceptionally severe.

But there are cases where nervous action has a very important and apparently direct relation to the cause of the inflammation. This may be illustrated by the following experiment. The sympathetic (vaso-constrictor) of the right ear and the auricular branches (vaso-dilator) of the left ear of a rabbit are severed, and the parts kept in water at a temperature of 54° C. In the case of the right ear there is an acute inflammation running a rapid course seeing that the vaso-dilator fibres have free play. In the case of the left ear, stasis and subsequently necrosis result in consequence of the uncontrolled action of the vaso-constrictor fibres.

In other cases the part played by the nervous system seems to be that of a carrier of impressions, in other words, we have an almost pure reflex action. By some the phenomenon of counter-irritation is explained in this way. The application of the actual cautery to the skin over an inflamed and painful joint will often relieve the pain and inflammation instantaneously. And Hilton laid down the law that the skin over a joint was supplied by the nerve supplying the joint itself and the muscles moving it. It is as if there was in the nerves of the part a state of over-action which affected injuriously the tissues, and increased the liability to an intensity of inflammation. This over-action being relieved by a still greater stimulation of nerves connected reflexly, the inflammation subsides.

The nervous system itself can scarcely act as an irritant, but it may so alter the tissues that agents which normally would produce no such effect will irritate and produce inflammation. The susceptibility of anæsthetic parts has been referred to above. In other cases, however, the nervous system, especially the central nervous system, plays a more important part. Simple exposure to cold will produce in some people a pneumonia, in others inflammation of the kidneys, in others a peritonitis. Such differences are difficult to explain except on the assumption that the central nervous system here plays an active, and not merely a passive, part. A state of the nervous system is probably induced which renders certain organs peculiarly liable to agents capable of inducing inflammation.

Besides this condition there are **Individual peculiarities, hereditary** or **acquired**, which can only be explained by an influence on the part of the nervous system. We need only cite the familiar instance of urticaria occurring in certain people after eating pears, strawberries, shell-fish, etc.

In studying individual cases of inflammation it will be important to consider **by what path the irritant has reached the part** which has become inflamed. In many cases it reaches it by the blood, and as the blood is distributed in every part of the organ, the inflammation will not probably show any special localization. And so, when we find two symmetrical organs, both of which are attacked in every region, we infer that the agent causing the inflammation has come by the blood, or, at least, by a path common to both. Of course, there may be local differences in the organ itself of such a character that every part will not be equally susceptible to the action of an agent calculated to produce inflammation, and so the disease may develop more in one part of the organ than in another, although the general character of its distribution will generally still suggest the path by which the agent has come.

I.—THE PRINCIPAL PHENOMENA OF ACUTE INFLAMMATION.

Looking to the cardinal signs of inflammation already enumerated, it will appear that two of them, namely redness and heat, are intimately related to the condition of the circulation, while the swelling may possibly have similar relations. John Hunter, in his conceptions of inflammation, regarded the phenomena as essentially connected with the state of the blood and blood-vessels. On the other hand, Virchow in his great work on cellular pathology emphasized the importance of the tissues, and regarded the phenomena of inflammation as due to a stimulation of the cells. Under the influence of the discovery, by Cohnheim, of the emigration of leucocytes from the vessels there was a reversion towards the vessels, and the attempt was made by this author to limit the term inflammation essentially to the phenomena connected with the vessels, and to regard it as a disturbance of the circulation. Still more recently Metchnikoff has attempted to limit inflammation to the activity of the amœboid cells of the body in their attempts to deal with intruding agents. He thus reduces inflammation to a process of Phagocytosis. In forming a complete picture of inflammation it is necessary to consider the whole phenomena in which nervous system, vessels, tissues, exudation, leucocytes, and phagocytes will all have their parts.

A simple **Experiment** may be performed to illustrate the principal phenomena at the outset of an acute inflammation. If a frog be paralyzed with curare, the web of the foot may be spread out and observed under the microscope. With a pair of scissors a superficial longitudinal wound may be made, taking care to remove little more than the epithelium. By this operation the connective tissue of the web, with its vessels, is exposed; the action of the scissors in cutting and the unusual exposure to the air, affect these structures, and the various phenomena of inflammation soon begin to manifest themselves. Care should be taken to keep a moist atmosphere around the web so as to prevent the wound, deprived of its epidermis, from drying. At first the circulation goes on in the bottom of the wound as before, the area is merely more transparent from the absence of the epithelium. But very soon, if an artery is near or in the wound, it dilates, and there is an acceleration of the stream in the capillaries and veins. But this soon disappears, and the circulation, especially in the capillaries, becomes slower and slower, till here and there the blood-corpuscles now and then stand still for a moment or two. By and by a peculiar condition becomes visible in the veins. Normally, the blood-corpuscles flow down the middle of the vein, and the peripheral zone contains plasma with a few white corpuscles rolling along. This is simply due to the fact that the specific gravity of the red blood-corpuscles is greater than that of the white. As the inflammation proceeds, the white corpuscles come to occupy this zone, and to adhere to the inner surface of the vessel. The individual corpuscles may not be all absolutely stagnant, they adhere for a time and then depart, but the result of the process is that there is a nearly complete filling up of the zone with white blood-corpuscles, so that the vein seems pavemented internally with these cells. This is seen not only in any vein which may happen to be in the bottom of the wound, but also in those for a short distance outside it.

If the attention be now directed to the surface of the wound it soon becomes manifest that certain peculiar bodies are appearing there. These are at first seen mostly towards the edge of the wound, and are especially numerous in the neighbourhood of veins where the white corpuscles are adherent. They are of various shapes, and present a transparent gelatinous appearance. If observed carefully they are seen to be altering their shapes, presenting the well-known amœboid movement, as shown in Fig. 31. These cells gradually increase in numbers, and by their contractile power, they move from the periphery towards the centre of the wound till they may come to cover it entirely. These bodies may be removed from the wound by placing the end of a capillary glass tube on the surface. A fluid runs up into the tube, and in the fluid are these free cells. The fluid may now be blown on to a glass slide and examined under a higher power of the microscope, when the slow amœboid movement will be still more manifest. If, in the drop of fluid, the bodies are allowed to die or are killed by the addition of a reagent, they become globular and granular, in fact, have the characters we recognize as those of white blood-corpuscles, lymph corpuscles, pus corpuscles—of leucocytes in general. The addition of acetic acid to the living cells will first cause them to assume the globular form, and then will bring out the nucleus or nuclei as in an ordinary white corpuscle. The fluid in which these corpuscles are found is coagulable, and if it be kept till the corpuscles have died strings of fibrine will be found in it. If this experiment be made in summer, the whole of those phenomena will manifest themselves in a few hours, and in five or six hours the entire wound may be plastered over with amœboid cells.

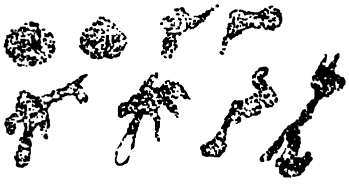

Fig. 31.—A leucocyte from human blood showing amœboid movement. (Klein.)

In the course of a few more hours the wound begins to be covered in with new-formed flat epithelium. This begins at the margins, and if the wound is small it may be wholly covered within twenty-four hours. The amœboid cells are covered in, but they very soon disappear, and the connective tissue of the web remains with a thin transparent epithelium covering it.

Without following out this experiment further, we may now proceed to consider the principal phenomena of inflammation, which have been partly illustrated. We shall consider, first, the state of the vessels; secondly, the condition which is illustrated in this experiment by the fluid on the surface of the wound containing amœboid cells; and lastly, the condition of the tissues in inflamed parts.

II.—THE STATE OF THE VESSELS IN ACUTE INFLAMMATION.

When an irritant is applied to a transparent vascular tissue, such as the tongue or web of the frog, it produces effects which vary slightly, according to its nature. If croton oil be applied, there is first a contraction of the arteries, extending to their whole length, followed by dilatation. If ammonia be used, there is dilatation without previous contraction. The dilatation affects chiefly arteries and veins, but also, though to a less extent, capillaries. The **dilatation of the arteries** leads to an **Active hyperæmia,** the current is accelerated in the arteries, capillaries, and veins, and these vessels are overfilled; there is a great excess in the quantity of blood passing through the vessels. The acceleration of the current does not persist, however, in the most affected parts; on the contrary, the blood-corpuscles begin to lag, especially in the capillaries and veins, although there is still acceleration in the arteries, and in the capillaries and veins of the less inflamed parts. This stagnation in the capillaries and veins may assume a high degree, especially in the part most acted on by the irritant. Although the current is slow in these vessels they remain overfilled, a **Passive hyperæmia** supervenes on the active hyperæmia; at the same time the white corpuscles accumulate along the internal wall of the veins in the manner already described, and they also adhere at intervals in the capillaries. The circulation may come almost to a standstill in the capillaries of the parts most affected, while at various distances out from this there will be manifest a less and less amount of retardation till a zone is reached where the retardation disappears, and by and by gives place to acceleration.

We have now to consider what may be the explanation of these various phenomena which the vessels manifest. The observations of Lister present us with a view of this subject which has been largely confirmed by other observers. Saviotti's researches are for the most part confirmatory of Lister's views.

Contraction of the arteries is not, in any proper sense, a part of the inflammatory phenomena. It is simply the result of stimulation of the nerves by the irritant, and while in the case of many irritants it does not occur at all, it is always transitory. Contraction of arteries may be produced either by reflex or direct irritation of nerves. It is produced reflexly by irritation of sensory nerves. Thus the arteries in the web of the frog's foot are seen to contract when the skin is tapped or twitched with the forceps. This contraction does not occur if the nerve trunks be first divided. On the other hand the irritant may cause contraction directly, by stimulating the vaso-constrictor nerve endings (as cold does), and so produce a temporary contraction of the arteries.

Dilatation of the arteries, leading to **active hyperæmia** (also called *determination of blood*), is induced by **paralysis of the arteries**, just as in other cases of active hyperæmia.

It is important here to recall the fact that **irritants act injuriously** on the tissues, and, in a certain sense, paralyze them. Lister in his important researches on inflammation brought this fact into prominence. The skin of the frog is supplied with pigment cells. These cells, as already illustrated, are contractile bodies. In the state of rest they are extended into numerous branches, which make a fine pigmented reticulum under the skin; in the active state they are drawn together so as to make a dark clump. They are under the command of the nervous system, and by their means the animal is capable of changing its colour, presenting a dark hue when the cells are relaxed, and a lighter colour according to the degree of concentration. Some irritants have the immediate effect of relaxing the pigment cells, and this itself is so far an evidence of paralysis, as the dispersed condition is the state of rest of the cells; but whether the pigment is dispersed or not, the animal loses control of its pigment in the affected area, which does not change its colour with the rest of the skin, and may be found dark while the animal is pale, etc.

In a similar manner the dilatation of the arteries is effected by a paralytic influence of the irritant. It is not easy to determine whether this paralytic influence is exercised through the peripheral ganglia, whose existence we have already seen reason to infer, or directly on the wall of the vessel, but as these ganglia are in or near the vessel-wall, we may infer that both are influenced. The view has been held that the dilatation is reflex, but this is excluded by the observations of Cohnheim. He found that if the sciatic nerve has been divided in a frog's leg the arteries dilate, but the application of an irritant produces a further dilatation. He found also that, after destruction of the brain and spinal cord, irritation of the tongue still produces dilatation of the arteries. The acceleration of the blood-current in the arteries, capillaries, and veins, will be understood from what has gone before to be a direct result of the dilatation of the arteries; we have, in fact, an active hyperæmia.

The Retardation is to be referred to an **increased adhesiveness** of the blood-corpuscles. This is a matter of direct observation. The corpuscles in the inflamed area can be seen to move sluggishly along the wall as if attracted by it, and the **Pavementing of the veins** with white corpuscles is clearly due to increased adhesiveness between the two, or to an attractiveness exercised on the leucocytes. The nature of this **attraction** will be considered later on. It has been pointed out by Lister that when the blood is removed from the vessels and comes in contact with dead matter, the blood-corpuscles acquire an adhesiveness which they do not possess inside the normal vessels. The red corpuscles stick together by their flat surfaces and form the well-known *rouleaux*. The adhesiveness of the white corpuscles is not so obvious when a drop of blood is examined outside the body, but there is reason to believe that it is even greater than that of the red. Now the irritant damages the walls of the vessels, with the result that the corpuscles behave as if in the presence of dead matter—they become adhesive.

This is excellently shown in one of Lister's experiments. He ligatured the leg of a frog, producing thereby stagnation of the blood in the vessels, but on examining the web it could be seen that the corpuscles were able to move freely among one another—there was obviously no adhesiveness. But now, when a piece of mustard was applied to the web, this free movement ceased in the area affected; the corpuscles became adherent among themselves and to the walls of the vessels. The result of this was an accumulation of the corpuscles in the irritated area; any corpuscles which happened to glide into the area remained adherent there, and so, by degrees, the vessels became overfilled—a state of hyperæmia superinduced on stagnation. If any corpuscle happened to escape from the affected area, it ceased to be adhesive, and moved freely about.

We may therefore infer that the retardation of the current and the pavementing of the veins with white corpuscles are the result of the injury to the vessel wall, and it may be added that, in connection with inflammations, all degrees of stagnation up to absolute stoppage or **Stasis** may be produced, and are often manifested together in the same case.

We may now **sum up** the conditions presented by the blood-vessels in the early period of inflammation as follows. The arteries dilate by a relaxation, of a paralytic character, of their muscular coats. In some cases this dilatation is preceded by an evanescent contraction. The immediate result of the dilatation of the arteries is active hyperæmia, or determination of blood, involving overfilling of the arteries, capillaries, and veins, with acceleration of the current. This is followed by retardation of the current, the vessels remaining dilated and hyperæmic, and this retardation may go on to almost complete stasis in the capillaries. The retardation is due to adhesiveness of the corpuscles, and to the same cause is to be traced the pavementing of the veins with white corpuscles.

It is sometimes possible in acute inflammation of the skin, as in the case of a boil, to observe conditions directly traceable to the state of the vessels here indicated. Thus at the peripheral parts of such a focus of inflammation the skin presents a fiery-red appearance due to determination of blood: the red colour may be pressed away with the finger, but it immediately returns. Inside this zone there is an area in which the redness is not so vivid, and when the red colour is pressed away it returns sluggishly; the corpuscles are here already adherent, and the current retarded. Then in the more central parts a dusky red appearance is presented, and on pressure it may be impossible or very difficult to remove the redness; here a condition of stagnation exists.

Increase of temperature in inflammation.—Calor is one of the cardinal signs of inflammation, and a feeling of heat is usually experienced when external parts are the seat of acute inflammation. In regard to internal parts, their nerves are not capable of conveying impressions of differences of temperature; a hot substance swallowed gives a sensation of pain. Many experiments have been made with a view to determining whether a part which is in a state of acute inflammation is the seat of increased production of heat.

There is no doubt that the temperature of external parts is increased in inflammation. John Hunter determined this by actual observation. He had a case of hydrocele to deal with, and undertook its treatment by the old operation of laying open the sac and inserting lint dipped in an irritating salve with a view to producing inflammation. At the time of the operation he found that the temperature in the tunica vaginalis was 92°, but next day, inflammation having been induced, the temperature had risen to 98¾°. The question here arises whether this increase of temperature is due to an actual production of heat in the inflamed part, or to an increased supply of hot blood, due to dilatation of the arteries.

That there is a **greatly increased supply of blood** to inflamed external parts has been proved by experiment and observation. Cohnheim found that in a recent inflammation produced by scalding the foreleg of a dog in hot water, or by painting with croton oil, the amount of blood issuing from a cannula inserted into a vein was greatly increased, sometimes reaching nearly double that issuing from a corresponding vein on the other side. It may even be as great as when the arteries have been relaxed in a limb by dividing the axillary plexus of nerves. This extreme degree of difference may not continue long, but even for some days it is frequently very considerable.

It is an every-day observation of surgeons that an incision in an inflamed part is accompanied by a much greater escape of blood than in a normal part, and if an artery be incised it spouts more blood and to a greater distance than a similar artery in a non-inflamed part. It is similar with the veins; Lawrence performed venesection in both arms in a person who had an acute inflammation of one hand, and he found that the blood flowed two or three times more rapidly from the vein on the side affected. The relaxation of the arteries in acute inflammation evidently produces a determination of blood which extends beyond the immediate focus of the inflammation, and is not counterbalanced by the retardation.

John Hunter, having determined the great increase in temperature above referred to, yet came to the conclusion that it was due to the determination of blood alone, for he found that the temperature of an inflamed external part never exceeded or even quite reached that of a normal internal part, or, in other words, of the blood in internal organs. Since Hunter's time, Simon has asserted that there is some development of heat in inflamed parts. His experiments seemed to show that the arterial blood passing to an inflamed external part is not so warm as the focus of inflammation, and that the venous blood returning from the part is warmer than the arterial blood, although not so warm as the focus of inflammation. But the experiments of Jacobsen, made with more exact instruments, entirely confirm the views of Hunter. It appears that the most intense inflammations of the skin or of muscles never cause an elevation of temperature sufficient to reach that of the rectum, vagina, or abdomen, the difference being generally 1° to 2° C. Again, in inflammations induced in internal parts, as the peritoneum or the pleura, the temperature was never raised to that of the blood in the left ventricle, being always from ·2° to ·5° C. under it. This means that in these parts, where the temperature is already near that of the blood in the left ventricle of the heart, inflammation, leading to an increased supply of blood of a similar temperature, causes virtually no elevation above the normal heat. Again, Cohnheim has found that, when in one fore-paw of a dog a state of acute inflammation is induced, while in the other active hyperæmia is produced by dividing the axillary plexus of nerves, the temperature in the inflamed foot is always slightly less than that in the other. We may safely infer, then, that in inflammation there is no local production of heat.

Fever often accompanies inflammation, but it only does so when the blood is affected. This may happen in one of two ways. The agent which caused the inflammation may be primarily in the blood, and it may produce both the general manifestations of fever and the local manifestations of inflammation. This applies to many infective agents. On the other hand, a local inflammation may give rise to products the absorption of which into the blood will cause fever. (See under Fever.)

III.—THE INFLAMMATORY EXUDATION.

In the experiment sketched at the outset the inflammatory exudation was the fluid which collected on the surface of the wound. We saw that this fluid contained amœboid cells, and that it was coagulable. We may thus consider the inflammatory exudation as consisting of cells, serous fluid, and fibrine, and we shall in the first place pass each of these under review.

1. **The serous exudation.**—The fluid derived from the blood passes in the direction of least resistance, wherever it finds room. In the case of a wound it flows from the surface, forming a serous **discharge**; in that of a mucous membrane it also flows from the surface, forming a **catarrh**; in serous cavities it accumulates, forming an inflammatory **dropsy**; in the tissues it passes into the serous spaces, constituting an inflammatory **œdema**; in the lungs it is situated in the lung alveoli, where it also produces œdema. The exuded fluid will in many cases find its way into the lymphatics, and experiment has proved that the current in the lymphatics is much increased in inflammation.

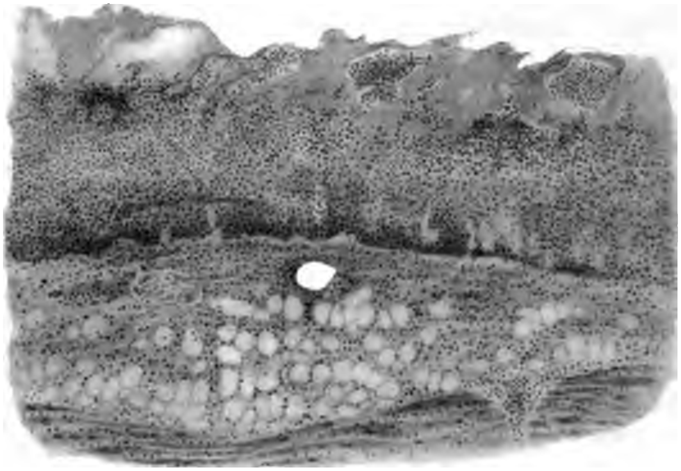

Fig. 32.—Acute pericarditis. The sub-pericardial fat, the inflamed pericardium and the fibrinous exudation on the free surface of the latter are shown.

The serous exudation is somewhat different in constitution from an ordinary transudation fluid. It is much more concentrated, approaching more nearly to the liquor sanguinis, and it contains more leucocytes than the exudation in simple œdema. It is also in many cases coagulable, so that when shed it may deposit fibrine, and sometimes does so in the living body. When this occurs we have the fibrinous exudation. We may associate these characters of the serous exudation with the fact that in acute inflammations the tissues, including the walls of the vessels, are seriously damaged, and the latter allow more readily of the escape of the fluid of the blood. The serous exudation filling the tissue spaces acts not only as a vehicle of nutriment to the cells and as a diluent to deleterious substances, but also acts as a carrier of certain bactericidal substances produced by the leucocytes, and possibly also by other cells. This will be referred to later on. (See Immunity.)

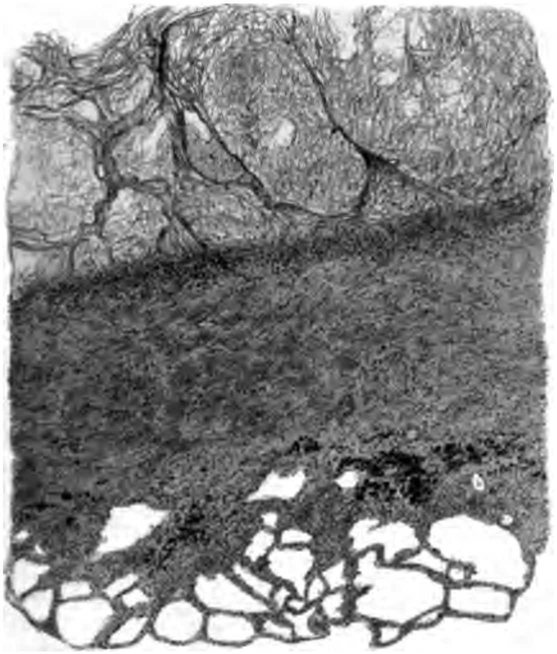

Fig. 33.—Acute Pleurisy. Fibrinous exudation on surface of greatly thickened pleura.

2. **The fibrinous exudation.**—This is seen most typically in acute inflammations of serous cavities such as the pericardium or pleura. (Figs. 32 and 33.) In such cases there is, in addition to the serous exudation occupying the cavity, a deposition on the surface of a soft yellow layer of coagulated fibrine. There is frequently a similar deposition on the surface of a freshly-inflicted wound, the fibrine forming a glaze on the surface, while the serous fluid passes off as a discharge. Fibrine is seldom deposited in the meshes of the tissues, unless there be an actual necrosis, as in the case of a boil or a

carbuncle, where the slough which forms in the skin is composed partly of dead tissue and partly of fibrine. In acute pneumonia, however, the exudation in the lung alveoli is fibrinous. (See Fig. 34.)

The term **Lymph**, or coagulable lymph, is often applied to the fibrinous exudation as seen on serous surfaces, but the use of this term is not to be commended. From its use by John Hunter the term has interesting historical relations, yet, as it implies a theory which is not now held, namely, that the so-called lymph has the power of developing into organized tissue, its use is apt to lead to confusion. This is all the more true, because the term lymph is frequently used in a very loose way to designate connective tissue formed as a result of inflammation. According to Hunter's view, the connective tissue develops directly from the fibrine, and so it was legitimately called lymph ; but as his views are now departed from, this use of the term is quite unwarranted.

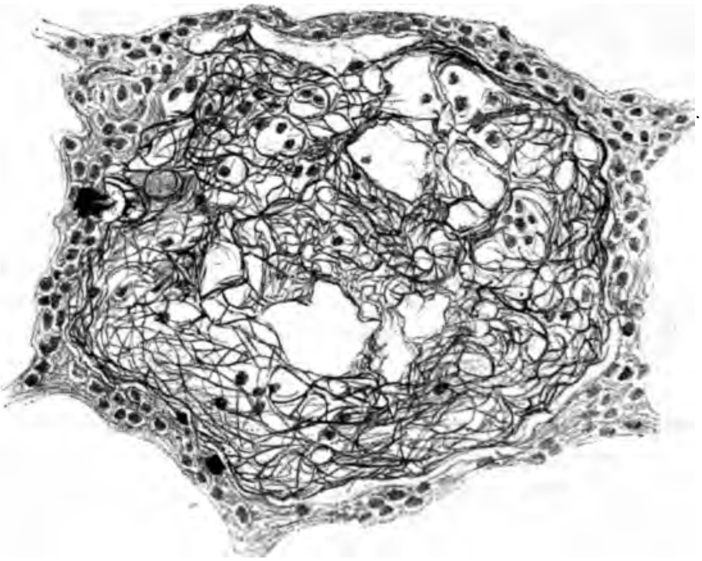

Fig 34.—Fibrine in a lung alveolus.

The fibrine of the exudation has all the characters of that in an ordinary blood-clot. This is shown in Fig. 34, where a network of fibres is seen filling a lung alveolus. It has also a similar origin to that in the blood-clot. We have seen (under Thrombosis) that coagulation of blood occurs when the necessary constituents are present and that in order to effect this there must be a disintegration of the leucocytes so as to yield the ferment. Leucocytes are always present in the serous exudation, and to bring about their disintegration they must be sufficiently removed from the influence of the living tissue. This can scarcely occur except in the case of an extended surface, as of a membrane. Just as thrombosis does not occur in the capillaries, because the blood in these narrow vessels is in intimate contact with the living cells forming the capillary walls, so in inflammation the fibrinous exudation scarcely occurs in the serous spaces unless there be actual necrosis of the tissue. In some very acute inflammations of connective tissue (acute phlegmon) there may be a deposition of fibrine, forming a kind of **fibrinous œdema**, such as sometimes occurs in the skin in erysipelas, but in these cases necrosis is a frequent if not a constant concomitant. It is where the exudation is on a surface, and is to a great extent removed from contact with the living endothelium, that the fibrinous exudation is most constantly found.

Epithelium, like endothelium, has the power of preventing the disintegration of the leucocytes, and hence a fibrinous exudation seldom occurs on a mucous membrane or the skin. Its occurrence implies that the epithelium has undergone necrosis or has been shed.

3. **Exudation of white and red blood-corpuscles.**—The resemblance of the cells met with in acute inflammations to the leucocytes in the blood long ago suggested the idea that they are white blood corpuscles. In the year 1846 Waller observed the pavementing of the internal coat of the veins with white blood-corpuscles in the inflamed tongue of the frog, and as he saw similar cells outside the vessel he inferred that the white corpuscles had got through the wall. It was, however, difficult to believe that the solid globular white corpuscles could pass through the intact wall of a blood-vessel, and Waller's views, although supported by William Addison, were lost sight of. The discovery by Recklinghausen that pus corpuscles and white blood-corpuscles possess contractile power by virtue of which they are able to move from place to place, and to alter their shapes in the most diverse fashion, paved the way for the actual observation of their passage through the walls of the vessels made by Cohnheim.

Emigration of white corpuscles.—This was observed by Cohnheim in the mesentery of the frog. When this exceedingly delicate and transparent structure is drawn out of the body through a wound in the lateral aspect of the abdomen, the mere exposure to the air is sufficient to set up an acute inflammation, the phenomena of which can be readily observed under the microscope. Let us suppose that the pavementing of the veins has occurred, and that there is an occasional white corpuscle adherent in the capillaries, the following surprising phenomena show themselves. The various steps as described by Cohnheim himself are represented in Fig. 35, in which the red corpuscles are left out in order to bring the leucocytes into prominence. "One sees, as a rule, first in a vein which presents the pavementing with white corpuscles, but sometimes in a capillary, a pointed projection in the external contour of the vessel; it pushes itself farther and farther outwards, it increases in thickness, and the pointed projection develops into a colourless rounded knob; this increases in length and thickness, sends out fresh points, and draws itself gradually outwards from the vessel-wall, with which it comes to be connected only by a long thin stem. Finally, this also lets go the vessel, and there lies outside a colourless, dull, glancing, contractile corpuscle, with several short processes and a long one, of the size of a white blood cell, with one or several nuclei; in a word, a white blood-corpuscle."

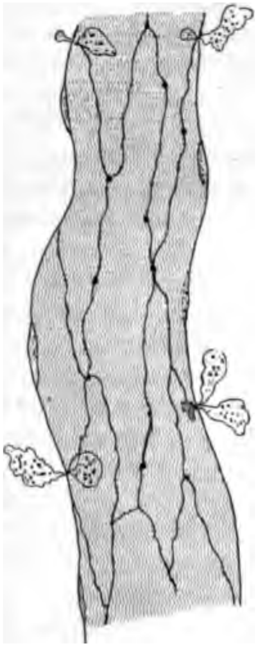

Fig. 35.—Diagram showing emigration of leucocytes in a capillary vessel. (After ARNOLD.)

Diapedesis of the red corpuscles.—This is a frequent accompaniment of acute inflammations. The white corpuscles are active contractile cells, and they generally pass through the vessels to a larger extent than the red ones, but there are some inflammations in which the red corpuscles also pass through in large numbers. They are not active, but are passively pushed through the walls, just as they are in the diapedesis of passive hyperæmia. As a rule diapedesis of the red blood-corpuscles follows the emigration of the leucocytes.

Explanation of the exudation of blood-corpuscles.—The red corpuscles and the leucocytes are so different in their characters that the same explanation can hardly apply to both. The **red corpuscles** are devoid of nuclei and possess no spontaneous movement. Hence their exudation, in inflammation as in passive hyperæmia, is a passive process. It is produced by pressure from within, and the altered condition of the vessel wall, as well as of the circulation, is an important element in its causation. That the state of the vessels is an important factor is evidenced by the fact that exudation of the red corpuscles is specially met with in the more severe forms of inflammation. As the red corpuscles are the coloured elements of the blood, inflammations in which they are specially exuded have a more or less hæmorrhagic character, and it is generally recognized that such conditions as hæmorrhagic pneumonia and hæmorrhagic small-pox are specially virulent forms of disease.

The leucocytes being active bodies have not such a merely passive part to play. They are amœboid cells, and pass out of the vessels by virtue of their inherent contractility. No doubt the altered state of the vessel wall renders it easier for the leucocytes to pass through. The leucocytes probably do not pass through the midst of the endothelial cells of the vessel wall, but through the cement between them. According to Arnold both the red and white pass out largely through pre-existing apertures or stomata. (See Fig. 19, p. 71, for the red, and Fig. 35 for the white.) As the corpuscles pass through apertures much narrower than themselves they undergo alterations in shape, so that the part actually in the wall is very attenuated. These apertures probably result from contractile changes in the endothelial cells.

As it is a characteristic feature of most acute inflammations that the leucocytes pass out of the vessels, and as they do so often in extraordinary numbers, some explanation of this fact must be sought. Light has been thrown on the matter by the researches of Metchnikoff and others. From the observation of unicellular organisms similar to the amœba, it appears that certain substances in solution are attractive to these bodies and others are repulsive. As this depends on the chemical nature of the substances, the terms **positive** and **negative chemiotaxis** have been introduced by Pfeffer. Pfeffer showed that a decoction of dead leaves attracts the plasmodia, whilst solutions of salt, sugar, and other substances repel them. As the leucocytes of the blood seem to be of a similar nature, it is not surprising that they also are liable to repulsion and attraction by different substances. Thus, with regard to the leucocytes, it has been observed that substances like croton oil and turpentine are positively chemiotactic, while others like chloroform and alcohol exercise an opposite effect. Further leucocytes are attracted by the majority of the microbes which induce inflammation, and Buchner has shown that the substances composing the bodies of bacteria—bacterio-proteins—and the products resulting from the breaking down of the tissues are similarly attractive. The extraordinary migration of leucocytes in many inflammations can scarcely be otherwise explained.

For example, Fig. 36 represents a lesion of the skin (sudamen), in which leucocytes have accumulated in a dilated sweat-duct. In order to reach this position they have not only penetrated the vessel wall, but insinuated themselves amongst the epidermic cells till they reached the interior of the duct. There seems no way of explaining this but by the view that the sweat contained some substance attractive to the leucocytes. It has diffused from the duct so as, in a dilute form, to reach the vessels and attract the leucocytes which have passed in the direction of its more concentrated presence.

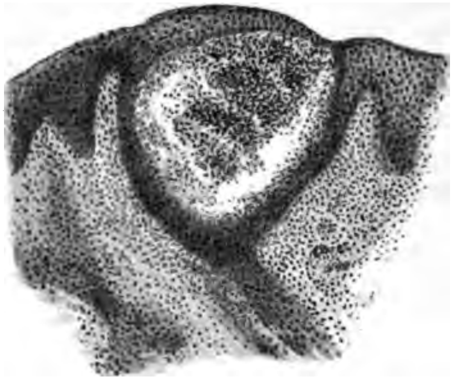

Fig. 36.—Sudamen formed by dilated sweat-duct. It is largely occupied by leucocytes attracted thither. ×80.

The corpuscles which leave the vessels in inflammation are almost exclusively the **polymorphonuclear** or **neutrophile leucocytes.** In stained sections the presence of leucocytes of this character can often be made out either in the tissue or along with the fibrine, as in Fig. 37. It has been suggested that this lobed character of the nucleus may be in order to allow of emigration, as the solid bulky nucleus of the other forms would have great difficulty in getting through the minute stomata (Metchnikoff).

This attractive power of some substances is supposed to have a special meaning, and the emigration of the leucocytes comes to occupy a central position in Metchnikoff's theory of inflammation. The amœboid cells of the various orders of animals have undoubtedly the power of englobing, and sometimes of digesting, solid granular matter. This power has relation either to the nutrition of the cell or to the protection of the organism. The cells may englobe foreign deleterious granules, and more particularly parasitic microbes, and even by destroying them rid the body of them. This process of **protective phagocytosis** is stated to be the explanation of the exudation of the leucocytes. It is generally a case of infection with microbes, and it

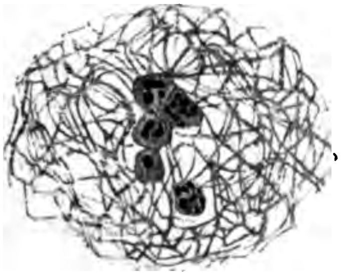

Fig. 37.—Polymorphonuclear leucocytes in fibrinous reticulum. From a lung alveolus in pneumonia.

is suggested that the chemical products evolved by them attract the leucocytes, which are induced to leave the vessels and encounter the microbes.

It is consistent with this view of the attractive power of certain substances that some inflammations are associated with little or no emigration of leucocytes. Thus we have serous inflammations in which there are few leucocytes. In inflammations produced by the bacillus of malignant œdema also there is abundant serous exudation, and frequently abundant red corpuscles, but the leucocytes are few. The poison produced by this microbe exercises apparently a negative chemiotaxis on the leucocytes. As a general rule it will be found that the more virulent the microbe the fewer the leucocytes and the less marked the phagocytosis.

4. **Cells from sources other than the blood.**—Still dealing with the inflammatory exudation, the question arises whether all the cells found in it are derived directly from the blood. The origin of leucocytes as a whole is somewhat obscure. The bone-marrow, spleen, and lymphatic glands are usually regarded as their principal sources, but the connective tissue as a whole, which is intimately related to the lymphatic system, is by many regarded as capable of giving origin to such cells. The study of the process of inflammation in connective tissues, and especially in such as possess no blood-vessels, seems to show that the **connective tissue corpuscles** are capable of giving rise to amœboid cells. These, however, have not the character of the exuded leucocyte, which, as we have seen, is, in the great majority of cases, of the polymorphonuclear variety. When examined in the tissues the nuclear distinction can generally be made out. Cells derived from the permanent tissues have probably more permanent characters than the exuded leucocytes.

Hoffmann and Recklinghausen produced inflammation in the cornea and then excised the eye or the head of the animal and preserved it in a moist chamber. They found in two or three days that at the seat of irritation groups of amœboid cells (pus corpuscles) had formed, as in ordinary keratitis. Then, also, several observers have described and figured the corneal corpuscles in inflammation, as drawing in their processes, and in doing so becoming amœboid. They also leave detached portions of their protoplasm which become pus corpuscles. It has also been asserted that the epithelium on the posterior surface of Descemet's membrane, as well as that on the surface of the cornea and elsewhere becomes, at the outset of inflammations, amœboid.

The cells met with in inflammatory exudations are not all of the character of leucocytes. They are sometimes larger and partake of the character of **derivatives of the epithelial cells.** This is more particularly the case in certain inflammations of the lung, where the alveoli are frequently occupied by cells which are evidently produced from the epithelium of the alveoli (so-called *catarrhal cells*). A similar formation of cells is frequently seen in the uriniferous tubules in inflammations of the kidneys. (See under Parenchymatous Changes.) Again, in suppuration in epithelial structures generally, amœboid cells are often found which are much larger than pus corpuscles and are derived from the epithelium. Neumann asserts that ciliated epithelium sometimes becomes amœboid and can be recognized, even after it has become detached, by the persistence of some of its cilia.

5. **The purulent exudation. Suppuration. Pus.**—Pus consists of a fluid portion, the liquor puris, and of pus corpuscles, which are identical with ordinary leucocytes.

Pus is met with under a variety of circumstances, but in nearly all cases it is produced by the action of microbes. The purulent exudation frequently follows the fibrinous exudation, especially in serous cavities, and it is not uncommon to find an intermediate condition in which the fibrine is, as it were, infiltrated with pus. This implies that the cause of the inflammation continues to act intensely. The emigration of leucocytes goes on vigorously, and these, crowding into the fibrinous coagulum, the latter disintegrates and liquefies, the liquefaction of the fibrine being perhaps equivalent to the necrosis of tissue which is implied in the formation of abscess, and being a specific effect of the toxin.

In the great majority of cases the microbes which cause suppurations—pyogenic microbes—belong to the class of micrococci, *e.g.* staphylococcus and streptococcus pyogenes, diplococcus, gonococcus, micrococcus tetragenus. But as we shall see later, other organisms may lead to suppuration, *e.g.* bacillus coli communis, bacillus typhosus, streptothrix actinomyces, and others.

Many experiments have been made in order to determine whether suppuration can be produced without the agency of microbes. From some of these, it appears that various substances, among them turpentine, mercury, solutions of nitrate of silver, and various essential oils, may induce suppuration, and that cadaverin, obtained from decomposing matters, but free from microbes, may do so. Koch has pointed out also that tuberculin obtained from cultures of the bacillus of tubercle, although free from microbes, is capable of producing suppuration. We may therefore infer that while suppuration may be produced by different active agents, yet in actual cases microbes are always present. We may also infer that it is by evolving irritating chemical principles (toxins) that they produce this effect.

It is not easy to understand why pus does not coagulate. There are abundant leucocytes, and there is the fluid presumably containing the fibrinogen. Moreover, a few pus corpuscles added to fresh liquor sanguinis induce coagulation. Its absence in pus has been ascribed to the existence of some chemical agent evolved by the micro-organisms which inhibits the process of coagulation, or to a conversion of the fibrinogen into peptones, which latter are known to be present in pus.

In the case of serous membranes the occurrence of suppuration implies a very intense inflammation, but in the case of mucous membranes pus is often produced when the inflammation is comparatively trivial. The ordinary catarrh of the nares and bronchi is first accompanied by a serous exudation, and this often gives place to an exudation of pus.

Purulent infiltration is a term applied when the suppuration occurs not at the surface but in the midst of the tissue, and the pus fills up the spaces, the condition being comparable, in respect of the locality of the exudation, with œdema. Purulent infiltration implies an intense inflammation, and it is almost necessarily associated with necrosis.

Abscess frequently follows purulent infiltration. The name abscess or **Apostema** is applied to a collection of pus in a cavity generally formed to accommodate it, although it is sometimes used in cases where the pus has accumulated in a pre-existing cavity. Purulent infiltration usually precedes, and the abscess is formed by the necrosis or liquefaction of the tissue, so that a cavity results. Hence abscesses often contain shreds of tissue or sloughs.

The abscess has often a distinct membrane forming its boundaries. This membrane is composed of granulation tissue, and it has often been regarded in the light of a secreting surface by which the pus is produced; hence the name **Pyogenic membrane** applied to it. The membrane, however, is by no means necessary to the formation of pus, and it is, in fact, a secondary product after the abscess has actually formed. Leucocytes penetrate the membrane passing from its vessels and from those of the surrounding tissue, and the abscess may enlarge. But the pyogenic membrane really limits the enlargement, as granulation tissue is less sensitive to irritants than other tissues, and is to be regarded as really a **protective layer**.

As abscesses contain the agents of inflammation which have produced the suppuration, they usually enlarge. This mostly occurs in the direction of least resistance, but gravitation often plays a part in the advance of an abscess. There is a gradual liquefaction of the tissue before the advancing pus, and this goes on, as a rule, till a surface is reached and the pus discharged.

A **cold abscess** is not really a collection of pus, but only of matter resembling pus. This is usually softened caseous matter, produced in connection with tuberculosis of bone, but pus corpuscles are often mixed with this debris. Cold abscesses frequently extend long distances, assisted by gravitation, before they reach the surface. Their opening, by admitting septic micrococci, may lead to acute suppuration within the cavity.

Pus, whether in abscesses or elsewhere, frequently **undergoes changes.** The pus corpuscles often undergo fatty degeneration, or they may swell up and disintegrate. The pus may in this way become absorbed. It sometimes, by absorption of its fluid, thickens into a pasty matter, in which lime salts may be deposited. Again, pus, or indeed a serous exudation, may be mixed with other matters, the secretion of glands, such as mucus, urine, or bile, or with oil, where suppuration occurs in a tissue rich in fat.

Croupous and diphtheritic exudations.—These terms have got into common use, but their employment is not to be recommended.

The croupous exudation is that which occurs in the larynx in croup, a disease of this organ. (The term croup is a Scotch word meaning the hoarse croaking sound of the cough and speech in certain laryngeal affections. It is nearly equivalent to the English word croak. It is by an extraordinary philological development that the terms croup and croupous have come to be used to designate the solid fibrinous exudation of disease.) The exudation in the larynx in croup is a whitish layer resembling fibrine, and by many regarded as a fibrinous exudation. Wagner believed that it arose by transformation of the epithelium and Weigert has asserted that it is due to a coagulation-necrosis of the epithelium.

The diphtheritic exudation implies a necrosis not only of the epithelium but of the mucous membrane. A fibrinous exudation occupies the meshes of the necrosed tissue as well as its surface, and it is consequently adherent to and involved in the membrane.

These terms, although originally applied to croup and diphtheria, are now frequently used in a purely anatomical sense of exudations on mucous membranes. A croupous exudation is one which lies on the surface and is not associated with necrosis of the mucous membrane, while a diphtheritic exudation is both on the surface and in the substance of the membrane and implies necrosis.

IV.—CHANGES IN THE TISSUES AND THE INFLAMMATORY NEW-FORMATION.

In what has gone before, the changes referred to have mainly concerned the blood-vessels and the various channels and spaces of the lymphatic system in connection with them. Besides these, however, we have to consider the changes in the tissues themselves, whether it be the proper parenchyma or the supporting structures forming the connective tissue. The proper tissue-changes are divisible in a general way into two, namely, those which concern the parenchyma or proper substance of organs, and which may be termed parenchymatous changes, and those which involve a new-formation of tissue and are met with chiefly in the connective tissues and the surface epithelium.

1. **Parenchymatous changes.**—In these we include the changes which occur in the proper substance of the tissues, the structures which perform the special functions of the parts. We have the numerous epithelial structures forming the secreting substance of glands, and we

have the parenchyma of nerve tissue, of muscle, of bone, of the lungs, etc.

In many acute inflammations the only obvious changes apart from the blood-vessels are degenerative, consisting mainly of necrosis and fatty degeneration. In many other cases, however, there are active changes visible in the parenchymatous cells, although it is also true that these are often associated with degenerative changes.

The active parenchymatous changes consist mainly of enlargement of the protoplasm, due to an infiltration with albuminous material. The cells acquire in consequence a granular clouded appearance, which is expressed in the name **Cloudy swelling**. (See under Albuminous Infiltration.) At the same time the cells frequently multiply, and they do this by the process of karyomitosis. The new-formed cells frequently depart from their position, especially in inflammations of epithelium. This process of **Desquamation** causes the cells to form sometimes a material part of exudations. (See above.) These phenomena of cloudy swelling and desquamation are frequently associated with **Fatty degeneration**. Another occasional sign of increased activity is an increase in the secretion of glands involved in inflammations. Thus the secretion of mucus is frequently increased in inflammations involving mucous membranes.

There are some inflammations in which these phenomena are so characteristic that Virchow's name of **Parenchymatous inflammation** is sometimes used for them. It may be presumed that the irritant in these cases, usually a morbid poison, has special affinities for the parenchymatous structures. It is not to be inferred, however, that the phenomena in the blood-vessels already described are absent. They are probably present in all cases, and they may be much more prominent during life than one would infer from the appearances after death.

2. **New-formation of tissue.**—In what has gone before the phenomena described have been chiefly those of the earlier periods of inflammation and hence of the acute stage. Some inflammations, however, have no acute stage, and others after an acute period become less intense; in both cases changes ensue which result chiefly in new-formation of tissue. It may be said, indeed, that most **Chronic inflammations** are characterized by new-formation. Besides this, much depends on the nature of the irritant. There are some agents which affect chiefly the blood-vessels, others which involve mainly the parenchyma, whilst others produce their effects mainly on the connective tissues, and lead to new-formation as their principal characteristic. The new-formed tissue sometimes exercises an important

function in serving as a bond of union between surfaces which have been separated, but it is very frequently of no such beneficial character. Thus both the tubercular and syphilitic infections are characterized by the formation of tissue, which in both cases shows commonly a degenerative tendency. The processes concerned in these and other similar diseases may be designated specific inflammations.

(*a*) **The Granulating Wound,** with its subsequent development into the **Cicatrix,** may be taken as a type of the inflammatory new-formation. (See Fig. 38.) On the infliction of a wound there are first the phenomena of acute inflammation with exudation of serous fluid and leucocytes such as have been already described. As the irritation of the actual infliction of the wound subsides, and provided the wound does not unite at once (first intention), a milder and more prolonged irritation usually ensues, caused in various ways by the friction of dressings, by decomposition of discharges, etc., with the result that so-called granulations cover the exposed surface. If the wound be carefully protected, by antiseptic precautions and otherwise, from all irritation, both mechanical and chemical, then the granulations do not form.

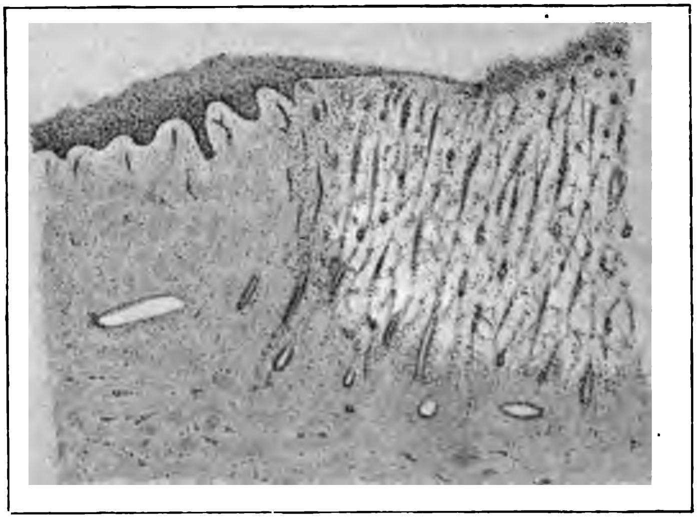

Fig. 38. Margin of granulating ulcer of leg. × 50.

Granulations present to the naked eye a red, somewhat irregular, surface, and consist of a highly cellular and highly vascular tissue. There is here new-formation of cells and blood-vessels. Among the **Cells** composing the granulations the following forms may be recognized:

polymorphonuclear leucocytes, formative cells, mononuclear and multinuclear cells.

The **polymorphonuclear leucocytes** (see Fig. 39) are small round cells with irregular or lobed nuclei which stain deeply. They are derived from the blood and form part of the exudation which granulations mostly yield. They are here merely in transit from the vessels to the surface or to the lymphatics. Their fate is to disappear. They play no part in the organization of the tissue, except in so far as they supply food for certain of the mononuclear cells. The absorption of these leucocytes by mononuclear cells is often evident. (See Fig. 40.)

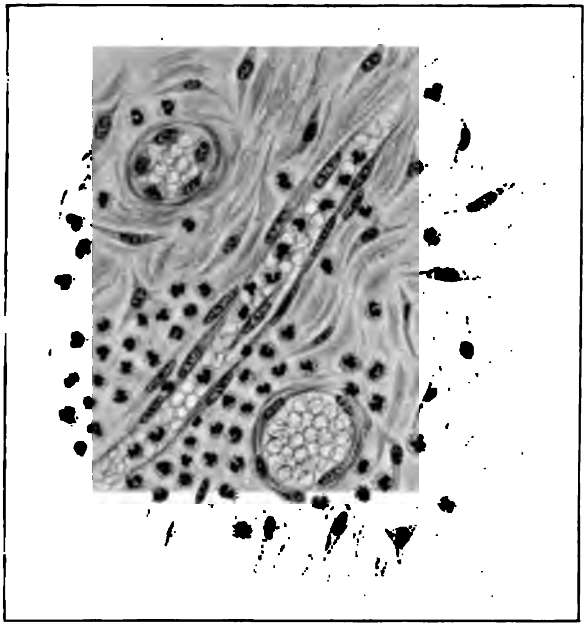

Fig. 39.—Emigration of polymorphonuclear leucocytes. Subcutaneous tissue in acute inflammation. × 400.

Formative Cells or **Fibroblasts**. (See Fig. 41.)—These are larger cells with round or oval nuclei and with a relatively abundant protoplasm. The shape of the cell varies. While the younger forms are rounded, the older approximate more to the type of the spindle. These are the true tissue cells of the granulations and are derived from preexisting connective tissue cells, and as they are concerned in the formation of the future permanent tissue they are called formative cells or fibroblasts. The term Epithelioid is sometimes less appropriately applied to these cells on account of their resemblance to epithelial cells.

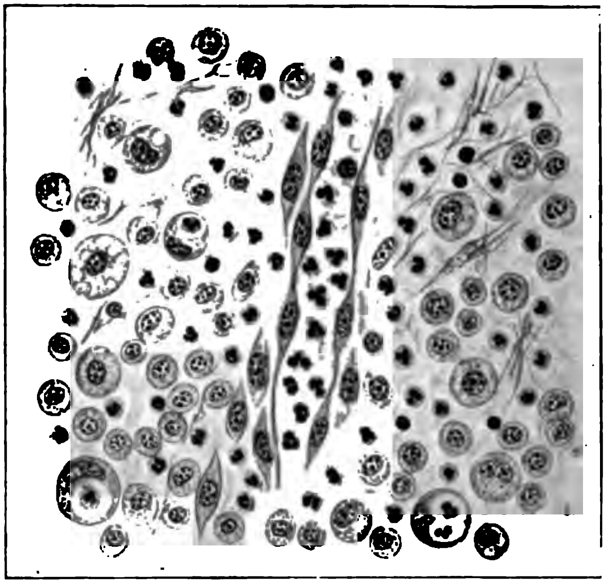

Fig. 40.—Active phagocytosis of polymorphonuclear leucocytes by mononuclear cells. × 400.

Mononuclear Cells. (See Fig. 40.)—These are cells with a single nucleus and a relatively large amount of protoplasm. In their morphological characters and properties they are indistinguishable from the large hyaline leucocytes of the blood on the one hand, and from fibroblasts, in one stage of their development, on the other. While it has not been definitely established that the mononuclear hyaline leucocytes of the blood develop into fibrous tissue, it is at least possible that they do so in the human subject. In certain of the lower animals, *e.g.* the tadpole, the transition from the leucocyte into a typical connective tissue cell has been repeatedly observed.

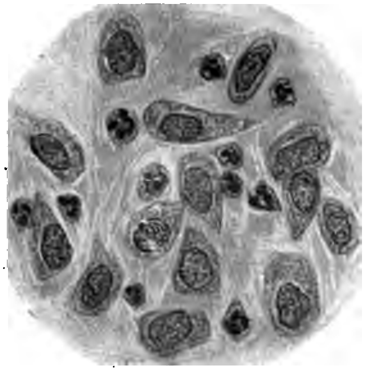

Fig. 41.—From superficial part of a granulating wound. Large formative cells and polymorphonuclear leucocytes are shown.

Multinuclear Cells or Giant Cells. (See Fig. 42.)—These are large cells, often considerably larger than the formative cells, with several nuclei. They are somewhat infrequent in ordinary granulation tissue, and are more characteristic of the specific inflammations. Evidently they may arise in more ways than one, such as by confluence of large mononuclear cells and by enlargement of formative cells, the nuclei of which divide without the cell protoplasm participating. They may play the part of phagocytes (see Fig. 42), and when their work is accomplished may divide up into smaller cells.

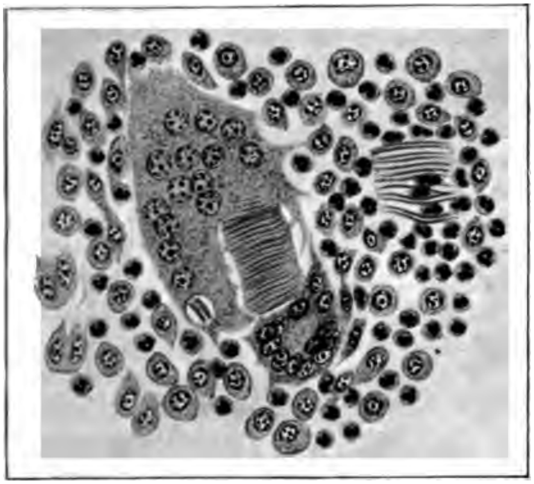

Fig. 42.—Absorption of muscular fibre by large multinucleated phagocytes. Polymorphonuclear leucocytes breaking up fibre. ×400.

In virtually all new-formed tissue of inflammatory origin, cells having the characters of the **small lymphocytes** are present.

The **Plasma-Cell** is a peculiar cell of varying outline, pyriform, ovoid or elongated, with usually an eccentric nucleus. The protoplasm stains blue with methylene blue, while the nucleus stains more lightly. The origin of this cell is doubtful. According to some it is derived from pre-existing or emigrated lymphocytes, according to others from emigrated large mononuclear leucocytes. The part played by this cell is not yet exactly known; it may be phagocytic. In certain round-celled infiltrations these cells may be present in large numbers.

The **Mast-Cell** (Mastzelle) of Ehrlich is another peculiar cell, the precise source and function of which is unknown. The protoplasm of the cell contains large numbers of basophile granules which stain red with methylene blue. Such cells are common in the neighbourhood of inflammatory areas.

The granulation tissue may be regarded as a kind of **embryonic tissue**, without the definite characters of any of the mature tissues of the body. Like embryonic tissue it has the power of developing mature tissue, but its powers are much more limited than those of the fœtal embryonic tissue. With the exception of the cells derived from epithelium at the edges of the wound it is **connective tissue** which the granulations are capable of forming. The granulation cells are mostly derived from connective tissue, and are inclined to pass back into the same kind of tissue. The first stage in this direction is an elongation of the cells, so that the more or less round formative cells become **spindle-shaped**. In the deeper parts of the granulating wound there are frequently considerable layers of spindle-cell tissue. (See Fig. 43.) The next stage is the formation of the fibrous intercellular substance, which occurs by the production of a homogeneous or fibrillated material between the cells. This arises by a kind of secretion on the part of the cells, and the latter at the same time shrink greatly and form the small elongated connective-tissue corpuscles of the cicatrix. The **Cicatrix** is thus composed of new-formed connective tissue; but it is imperfectly formed, the intercellular substance being usually denser than that of ordinary connective tissue, and with a tendency to **shrink** which often lasts long after its first formation.

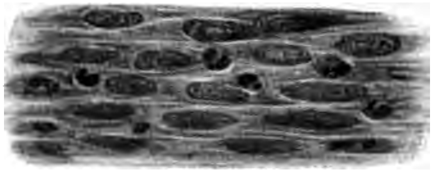

Fig. 43.—From deeper part of a granulating wound. Spindle-shaped cells with occasional polymorpho-nuclear leucocytes are shown.

The **blood-vessels** of the granulating wound form a rich system of capillaries, mostly in the form of loops passing towards the surface and returning. (See Figs. 38 and 44.) They form by a process of **budding** from the existing vessels of the part. The protoplasm of one of the cells in the wall of a small artery or capillary protrudes outward, like a bud, and extends to a neighbouring vessel, or to a corresponding process from another vessel. In this way solid arches (see Fig. 44) are formed which increase in thickness. The vessels are formed by the tunnelling

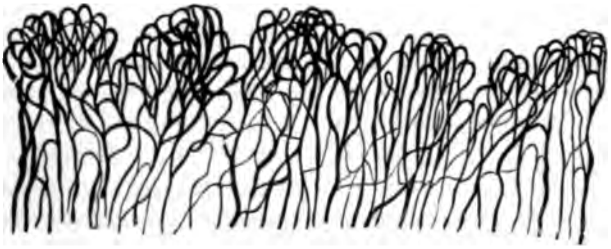

Fig. 44.—Vessels of a granulating wound injected. (BILLROTH.)

of these. It has been asserted that the tunnelling takes place by the conversion of some of the protoplasm into red corpuscles in a manner similar to that which occurs in the original formation of vessels in the embryo, but this is very doubtful. According to Thiersch blood-vessels may be formed by a process of channelling among the cells. The wall of the vessel, infiltrated and softened by the inflammation, allows the blood plasma to pass out, and this forms canals which widen and admit the blood-corpuscles, but this is doubted by other authors, such as Arnold and Yamagiwa.

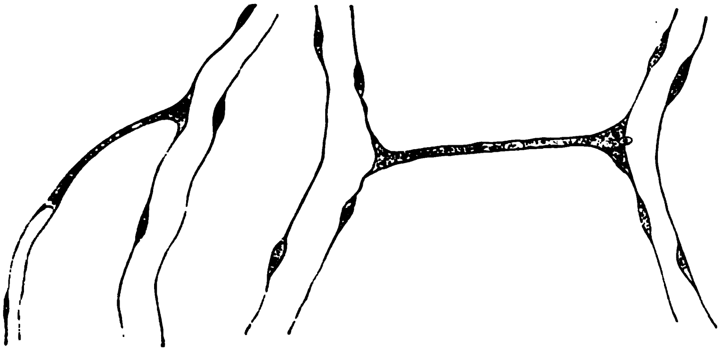

Fig. 45.—New-formation of blood-vessels in a granulating wound. (After ARNOLD.)

Bone and cartilage are, histologically, forms of connective tissue, and they are, in pathological processes, to some extent interchangeable with ordinary connective tissue. Hence in inflammatory new-formations we may have, according to circumstances, these tissues produced along with or instead of connective tissue. This applies more particularly to inflammations in connection with bone. In fractures, for example, the so-called callus is composed, in many cases, of all three tissues.

The New-formation of epithelium is an essential part of the process of the conversion of a granulating wound into a cicatrix. To some extent the cells at the margins of the granulating wound are derived from the epidermic cells, and these will develop into epidermis. The new epithelium, however, is derived to a large extent more directly by karyomitosis from the surrounding epidermic cells. Hence this part of the process occurs usually at the margins of the wound, and will only take place in the midst of the wound if epithelial structures such as hair follicles or glands survive there. A certain limited amœboid movement is asserted by which the young epithelium passes into its proper place. The newly-formed epithelium is translucent and delicate, so that the granulations beneath show their colour through it. The epithelium remains somewhat translucent, like that of the stratum lucidum of the epidermis, and there is not in the cicatrix a formation of a proper Malpighian layer. Living epithelium may be transplanted from a distant part or from another person to the surface of a wound where it may multiply. (See under Transplantation.)

(*b*) **Other inflammatory new-formations** present processes which in their elements are similar to those just described. For new-formation to occur the inflammation must be prolonged for a considerable time, and it must not be too severe, hence it usually arises as the result of a **chronic inflammation.** As it is connective tissue which is chiefly concerned in this process, the result is in most cases an increase of existing connective tissue. In such cases the process does not go through such definite stages as in the case of the granulating wound, but the various steps are present side by side. The tissue shows leucocytes, formative cells, and fully-formed connective tissue.

A brief consideration of the distribution of the connective tissue will indicate the general characters of the inflammatory new-formation. **Membranes**, such as serous and mucous membranes, undergo great thickening of their connective-tissue structures. As **serous membranes** are essentially composed of this tissue there is simply a thickening of these. (See under Chronic Pleurisy and Chronic Peritonitis.) The same applies to the **endocardium** of the heart and the **intima** of blood-vessels, which are connective-tissue membranes and, in chronic inflammations, undergo thickenings. (See under Chronic Endocarditis and Endarteritis.) **Mucous membranes** contain glandular structures, and the thickening and shrinking of the connective tissue may cause atrophy of the former, and actual thinning of the mucous membrane as a whole. (See under Chronic Bronchitis.) On the other hand, there may be a great thickening of the mucous membrane, especially where the glands are few or simple in structure. This inflammatory thickening may occur irregularly, and there is sometimes a localized formation of tissue which projects from the surface and forms tumour-like outgrowths, the so-called **Mucous polypi**, such as are found in the uterus, nares, larynx, intestine, etc. In some cases there is a new-formation of gland tissue along with connective tissue, and the polypi may thus be more complex in structure.

In **parenchymatous organs**, such as the **liver** and **kidney**, there is a stroma of connective tissue supporting the proper tissue, and carrying blood-vessels, lymphatics, and ducts. In chronic inflammations this undergoes increase, and often leads to atrophy of the proper tissue and shrinking of the whole organ.

Foreign bodies, or dead pieces of tissue, frequently give rise to inflammatory new-formation. A foreign body introduced among the living tissues, if not very virulent in its own nature, sets up a mild chronic inflammation, with the result of producing a vascular rudimentary tissue like granulations. If the foreign body be permeable by this tissue, then the granulations grow into it, and, as it were, devour it, replacing it first by their own rudimentary tissue, which afterwards gives place to connective tissue. As this connective tissue is comparatively small in bulk, and tends to contract more and more, the result of the whole process is an **absorption of the foreign or dead substance** and the gradual disappearance both of it and of the tissue which has replaced it. But if the foreign body be not permeable, or only partially so, then the inflammation results in the production of a layer of connective tissue around it, and so the body becomes **encapsuled.**

Many instances of this might be given. If a piece of dead animal tissue be introduced into the body, as, for instance, a piece of liver previously hardened in chromic acid solution, or a piece of prepared catgut used to ligature a vessel, then the dead tissue is first replaced by rudimentary tissue and gradually shrinks away. Again, if a piece of a tissue or organ dies, then, if severe inflammation is kept off, it is replaced by rudimentary tissue and absorbed. In fractures of bones it often happens that a piece is entirely separated and dies. Such a piece of bone may lie exposed in the wound in a compound fracture, and it has frequently been seen how it has been eaten into by the granulations and absorbed by them.

The encapsuling of foreign bodies is frequently seen. A parasite such as the trichina or echinococcus obtains a connective-tissue capsule. Dead material in the body which is not permeable by the granulations is similarly treated, such as dried-in inflammatory products, which have formed first a caseous and then a calcareous mass. We frequently find such calcareous material surrounded by a fibrous capsule in the lungs and elsewhere.

Attempts have been made to limit the use of the term Inflammation to the phenomena described as those of the earlier periods, and which are concerned especially with the vessels and their contents. The new-formation of tissue is thus excluded, mainly on the ground that it is reparatory, and that it often occurs without any of the phenomena of acute inflammation. Whilst it may be acknowledged that increase of connective tissue may occur as a consequence of atrophy of the proper parenchyma, and without any indication of inflammation, yet it must be added that, if we include the etiological factor in our definition of inflammation, much of fibrous new-formation is inflammatory. Taking inflammation as the ordinary phenomena which result from the action of agents which directly damage the tissues, we must include those cases in which there is a prolonged action, slight at its onset, as well as those in which the onset is abrupt and the influence severe.

Moreover, if we are to separate as non-inflammatory the processes which are reparatory, then this principle must be applied to all stages of the process. It will be found impossible, in regard to such typically inflammatory phenomena as active congestion and exudation, to say to what extent restorative processes are involved, as, for example, in the emigration of leucocytes. Discussion has mainly arisen on the question of the so-called chronic interstitial inflammations of the liver and kidney, and the decision has been made to hinge on the question whether degeneration of the parenchymatous tissue precedes the new-formation of connective tissue or not. To the author it appears that this is a wrong issue. The question is rather, whether or not the diseases are due to chronic irritation of these organs by noxious agents. If the irritant act characteristically on both tissues, or if it act primarily on one, it is none the less inflammatory. The author decidedly inclines to the view that cirrhosis of the liver, which occurs in a form characterized by great and evidently primary new-formation of connective tissue, is inflammatory, and he has come to the same conclusion as to the corresponding disease of the kidney.

V.—THE ISSUES OF INFLAMMATION.

The manner in which inflammations conduct themselves till their conclusion, and the results which remain, have, to a large extent, been explained in what has gone before. We have here briefly to gather up the facts and bring them into relation.

1. **Resolution, or Restitutio ad integrum.**—These terms are applied to the subsidence of the inflammation and a restoration of the parts to their previous normal condition. This can scarcely take place except in acute and transient inflammations, as the occurrence of new-formation constitutes a more or less permanent lesion. In the case of acute inflammations, when the irritant ceases to act, the phenomena, so far as the blood-vessels are concerned, will soon cease, and there will remain to be dealt with the exudation and the alteration of the tissues. The exudation, so far as it consists of serous fluid and leucocytes, is, as a rule, readily absorbed. It is generally situated so as to be in immediate communication with the lymphatics, and the leucocytes, by their own movement, may pass into these. Where absorption is not so readily effected, the cells frequently undergo fatty degeneration; and this applies to other cells which may be in the exudation besides leucocytes. Cells which have undergone fatty degeneration readily disintegrate, and the resulting fatty matter is absorbed. In like manner, the fibrinous exudation may undergo disintegration, and be absorbed or discharged.

2. **Adhesion of inflamed surfaces** is a frequent result of new-formation. In the case of the granulating wound, if two granulating surfaces, such as the flaps of a stump, be brought together, they coalesce, and the two layers ultimately form a single bond of union,

the cicatrix. There may be, in some cases, a regeneration of tissue which may have been lost, but this is generally imperfect. (See under Regeneration.) Adhesion occurs in other cases as well. The inflamed surfaces of pleura, pericardium, peritoneum, etc., commonly coalesce and form permanent adhesions, composed of connective tissue. By means of these adhesions the blood-vessels of the two surfaces communicate, and the adhesion is a permanent one, the cavity being obliterated so far as adhesion has occurred.

3. **Induration** is a frequent result when the connective tissue of an organ or a considerable portion of tissue is affected by chronic inflammation. The new-formed connective tissue, like that of the cicatrix, is dense, and tends to shrink. Hence the structures are rendered more dense and processes result which are sometimes designated by the term **Sclerosis.**

4. **Necrosis**, or death of tissue, is a frequent issue of acute inflammation. The dead tissue may be absorbed in the manner already referred to, or it may be discharged as a slough.

VI.—SYSTEMIC CHANGES RESULTING FROM INFLAMMATION.

We have hitherto dealt mainly with the local changes in inflammation. There are, however, associated changes in the general system which here must receive notice. Of these the changes in the circulating blood are the most important. It will suffice for the present to note the changes in the blood generally and those concerning the leucocytes particularly. In extensive acute inflammations, owing to loss of fluid by exudation the blood becomes inspissated and its specific gravity is increased. Sherrington has shown experimentally that this alteration may persist for more than sixty hours after the infliction of the injury. Within recent times much attention has been directed to the leucocytes present in the blood in inflammatory conditions. In some, if not in most inflammations, there is a marked increase in the number of leucocytes present in the circulating blood—a **Leucocytosis.** This may be preceded by an actual diminution in their number—a **Leucopenia,** as it is called. This subject will be more fully considered later on. (See under Blood.)

VII.—TERMINOLOGY OF INFLAMMATION.

We have had occasion already to notice that the various phenomena of inflammation are not always present in every case, and one or other of them may be so pronounced as to give its character to the inflammation. Hence, names have been given according as the inflammation shows certain special characters.

In the various forms of inflammation now to be mentioned, it is not to be supposed that a classification of inflammations is attempted. These are merely names in current use which call for explanation.

1. **Parenchymatous inflammation** is a term introduced by Virchow to indicate that the inflammation affects mainly the proper tissue elements. It is characterized chiefly by cloudy swelling and fatty degeneration of the structures.

2. **Interstitial inflammation** is almost the converse of that just mentioned. In it the inflammation affects chiefly the connective tissue, which forms the supporting stroma of organs. In acute inflammations there will be an infiltration of the connective tissue with leucocytes, and in some cases this may be so intense as to give rise to infiltration of pus. In chronic inflammations there will be new-formation of tissue, usually resulting in **induration.** A frequent consequence of chronic interstitial inflammation is atrophy of the proper parenchyma of the organ, produced by the shrinking of the connective tissue, but also partly by the action of the irritant on the parenchymatous structures.

3. **Suppurative inflammation.**—From what has gone before it will appear that, for the most part, it is in intense inflammations produced by virulent microbes that suppuration occurs. **Phlegmonous inflammation** is a name given to very acute inflammations accompanied by suppuration and necrosis. It is usually applied to inflammations of that character in the skin and subcutaneous tissue, of which erysipelas affords the best example.

4. **Infective inflammation** implies the presence of microbes, which by their multiplication produce an extension of the inflammation from its original seat. The infection usually extends locally by means of the serous spaces and lymphatics (as in erysipelas), or it may be carried by the blood to distant parts, and produce inflammations by **metastasis.** (See under Infective Embolism.) The infective inflammations are mostly suppurative.

5. **Ulcerative inflammation, Ulceration.**—These terms imply necrosis or loss of tissue, generally of a progressive character. The loss of tissue may be rapid, and involve the formation of visible sloughs, or it may be gradual, a molecular necrosis, the dead particles being absorbed or removed in the exudation. These results are produced by very intense irritants, and the inflammations are usually of an infective and suppurative character. While ulceration expresses the process of progressive destruction of tissue, the ulcer is the open exposed gap in the tissue. If the ulceration pauses, then the ulcer becomes covered with granulations and is converted into a granulating wound.

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SECTION V.

INFECTION AND INFECTIVE DISEASES.

I. **General facts with regard to Infection, Infective and Infectious diseases.** (*a*) Local infection. (*b*) General toxic effects. (*c*) Infection of the blood. II. **Susceptibility to infection. Immunity.** (1) Natural Immunity. (2) Acquired Immunity. (3) Artificial Immunity. (*a*) Active. (*b*) Passive. (4) Toxins and Antitoxins. (5) Theories of Immunity. (6) Duration of Acquired and Artificial Immunity. III. **Infective diseases.** i. **Septic Infection.** Definition. Mode of induction. Suppuration. Purulent infiltration. Abscess. Septic infection of cutaneous and mucous surfaces. Septic infection in serous cavities. General symptoms resulting from septic infection. The pyogenic microbes. ii. **Acute Specific Diseases.** A. **Diseases of uncertain microbic origin**—Acute specific fevers mainly.—Small-pox, Chicken-pox, Scarlet fever, Measles, German Measles, Typhus fever, Yellow fever, Whooping Cough, Mumps, Rheumatic fever, Dengue, etc. B. **Diseases of certain microbic origin.** Erysipelas, Influenza, Plague, Malta fever. Anthrax and Symptomatic Anthrax. Malignant Œdema. Relapsing fever and many others referred to in special part of work. iii. **Infective Tumours. Specific New-formations.** New-formations due to specific morbid poisons, which in most have been determined. i. **Syphilis.**—The primary lesion, or Hunterian chancre; affection of lymphatic glands. The secondary lesion, the virus in the blood. The tertiary lesion, gummata; amyloid disease; affection of arteries. Hereditary and congenital syphilis. ii. **Tuberculosis.**—Causation, the bacillus; tuberculosis by inoculation; contagiousness; inheritance. Character of the lesion, the miliary tubercle; how produced; caseous necrosis; fibrous transformation; softening and ulceration. Local tuberculosis; mode of access of bacillus; extension of local process, by lymphatics and along surfaces; effects of local tuberculosis, emaciation, fever, etc. General tuberculosis, or acute miliary tuberculosis. Tuberculosis in animals. iii. **Leprosy**; the bacillus; character of lesions in tubercular and anæsthetic forms. iv. **Elephantiasis**; causation from unknown morbid poison; character of lesion. v. **Glanders**; causation and character of lesion. vi. **Actinomycosis. Madura disease**; causation; character of lesions and locality. vii. **Hodgkin's disease**; character of lesion. **Framboesia. Granuloma Fungoides** (see under Diseases of Skin).

I.—GENERAL FACTS OF INFECTION.

INFECTION is a general term used to designate the production of disease by agents which, penetrating into the body from without, multiply in the body, spreading either locally, or by means of the blood, to the tissues generally. Such infective agents have been proved in many cases to be minute parasites belonging to the vegetable or animal kingdom, and it is generally believed that it is so in all. **Infective diseases** are such as have the character of infection, and the term must be distinguished from **infectious diseases**, as the latter conveys the idea of direct communication of the disease from a person or animal already infected, whereas infective diseases, whilst including infectious, also cover such as may be derived from without, without the intermediation of a living infected person. Thus septic processes, malarial fevers, etc., are infective but not infectious. **Contagious** has a similar meaning to infectious, but implies an even more immediate contact by means of which the infection is conveyed.

The infective agents in so far as they have been determined belong to the lower members of the vegetable and animal kingdoms, the adjective **pathogenic** being applied to such members of these classes as are capable of infecting the bodies of animals and producing disease. The specific forms of parasites are described further on, but it may be noted here that, with the exception of a few unimportant fungi, they all belong to the microscopic forms of the vegetable kingdom which are generally called **Bacteria**, or to microscopic forms of the animal kingdom belonging to the **Protozoa**. As both forms are microscopic the general term **Microbes** may be applied, and Pathogenic Microbes will include the greater part of the known infective agents.

The infective agents produce their effects by means of poisons or **toxins**. Probably in all cases the poisons evolved by the microbes produce effects on the structures immediately in contact with them, but in almost all cases the toxins do not limit themselves to this local action, but pass into the blood, and there are some forms of disease in which the microbe propagates in the blood itself and the toxins are primarily formed there. We recognize, therefore, a local and a general action, and where these co-exist in the same form of disease they may be of varying intensity in relation to one another. In these respects we are able to recognize several different categories.

(*a*) **Local Infection.**—The most important local effects are inflammation, sometimes associated with necrosis. That is to say, the toxin may kill the tissue; but short of that, and, it may be, around the dead structure, there is inflammation. In almost all cases the toxins, although their action may be mainly local, are to some extent diffused outwards, and pass into the blood so as to produce general effects.

(*b*) **General toxic effects.**—The toxins, as just noted, are liable to pass from the infected locality, and produce general effects by entering the blood. It is here a question not of microbes passing into the blood, but of their toxic products; it is a **poisoning** of the blood, **not an infection.**

The general toxic effects vary according to the nature of the poison. In most cases **fever** is produced, as in tuberculosis, septic infection, diphtheria, etc. In others there are more **specific effects**, such as muscular spasms in tetanus and hydrophobia, soporific conditions in cholera, etc.

In some forms the poison given off is of extraordinary intensity, and the disease is dangerous to life chiefly or entirely from the general toxic action. The most striking example of this is tetanus, where the microbe propagates locally with quite insignificant effects, but gives off a toxin of almost incredible virulence. Another instance is afforded by diphtheria, in which, although there are important local phenomena, the general toxic influence is especially dangerous. Diseases in which, as in tetanus and diphtheria, there is a specific general poisoning are sometimes called **toxic diseases.** In these and other cases the toxins may be elaborated by the agents when growing in artificial cultures, and the general symptoms of the disease may be produced by the introduction of the toxins separated from the microbes by filtration or otherwise.

As will be pointed out, auto-intoxication may result from the absorption of poisons from agents which are not properly infective. Putrid matters after separation of the microbes causing putrescence produce symptoms when injected into the bodies of animals. Foods which have undergone certain fermentative changes of unknown character may acquire poisonous properties, and their decomposition in the intestinal canal may evolve products whose absorption produces symptoms.

(*c*) **Infection of the blood. Septicæmia and Pyæmia.**—In contrast with the conditions mentioned above, in which only the products of the infective agents pass into the blood, we have cases in which the agents themselves propagate in the blood. To this class of diseases, characterized by blood-infection in addition to a poisoning of the blood by toxins (toxæmia), the terms **Septicæmia** and **Pyæmia** are applied. The former term indicates a condition in which the blood is invaded by organisms which propagate actively within it, but which is unaccompanied by suppurative manifestations in the various organs. Such a condition is well exemplified in guinea pigs which have been inoculated with anthrax, or in the naturally occurring disease ("Splenic Fever"), in other animals.

In pyæmia, on the other hand, the presence of organisms in the circulating blood is necessarily accompanied by local suppurative effects in the form of metastatic abscesses. It will be apparent that, in the latter condition, the presence in the blood of pyogenic organisms is implied.

II.—SUSCEPTIBILITY TO INFECTION. IMMUNITY.

The introduction of infective agents or their toxins into animals is by no means followed by the same results in all cases, and we are thus met with the fact of varying susceptibility amongst animals. We are able to recognize several kinds of variation in this respect. Animals by their inherited constitution present various degrees of susceptibility. Some are naturally insusceptible to certain microbes or their toxins. Hence we speak of **Natural Immunity** (*Innate Immunity*). Then it is well known that in many cases when an animal has passed through a single attack of an infective disease it is rendered more or less insusceptible of a second attack. The immunity thus conferred is spoken of as **Acquired Immunity.** Again, by certain experimental methods of procedure an animal may be rendered insusceptible in various degrees. This constitutes **Artificial Immunity.** The terms immunity and immune are used as equivalent to insusceptibility and insusceptible, and are employed in relation to a given disease or microbe or toxin. Further, they are used as relative and not as absolute terms.

1. **Natural Immunity.**—This subject has been sufficiently illustrated at pp. 21 and 22, where it is pointed out that, as a part of the generic, specific, racial, and individual characters, there are great differences in the reception which the pathogenic agents receive from different animals. Indeed, the designation pathogenic is to be used relatively to particular animals. A microbe is pathogenic in some animals and non-pathogenic in others, or, in other words, some animals are susceptible to a particular infection and others are immune.

No clear explanation of this fact is, as yet, forthcoming, but it is very probable that the agencies here at work are similar to those which are effectual in producing artificial immunity.

2. **Acquired Immunity.**—It is well known that in the case of some of the infective diseases the survival of one attack causes a certain immunity to further attacks. This applies to most of the specific fevers, such as small-pox, typhoid, and scarlet fever. In most diseases of this kind (the Exanthemata) no microbe has been discovered, but in typhoid fever, which is one of the exanthemata and is subject to the same rule of immunity, the microbe is a specific bacillus. The immunity in cases of this kind is conferred by the infective agent or

its products, and is probably the same as in the case of artificial immunity.

3. **Artificial Immunity.**—Different terms are employed to designate the manner in which immunity is brought about artificially. If it is produced directly it is spoken of as **active immunity**, if indirectly, as **passive immunity**.

Active Immunity.—This is produced by the direct introduction into an animal of a microbe or its toxin. The living microbe may be used in its virulent form in small doses, or its virulence may be tempered or attenuated, as it is called, in various ways, such as by exposing the cultures to a slightly higher or lower temperature than suits their habit, as in the case of the anthrax bacillus; by cultivating for a prolonged time on artificial media; by passing the microbes through the body of another animal; by adding certain chemical substances to the cultures, etc. These attenuated cultures are spoken of as **Vaccines**. By various modifications of the above-mentioned methods vaccines have been prepared of a number of diseases, of which the principal are cholera (Haffkine), anthrax, fowl cholera, hog erysipelas, symptomatic anthrax, and rabies.

It will be readily surmised that these comparatively recent methods devised to bring about active immunity have been suggested by vaccination. By **vaccination** immunity to small-pox is induced by the introduction of the virus of a disease which is either an allied condition or a weakened form of the disease against which protection is sought.

Passive Immunity.—Here as we have seen immunity is indirectly affected. The serum of an animal which has been rendered highly immune, by the methods employed in producing active immunity, is taken and injected into the body of another animal. The serum which is selected may be the serum of an animal immune to a certain toxin (**antitoxic serum**) or to a special active and virulent microbe (**antimicrobic** or **antibacterial serum**). The result is that immunity to the particular form of infection is conferred. It has been further shown that the serum added to the toxins produced by artificial cultures renders these toxins innocuous when injected into animals. These facts, which were established by Behring and Kitasato in the case of tetanus and diphtheria, imply that in the immunized animal a substance is produced which antagonizes the toxin, and is therefore called **antitoxin**. There have been established on this basis methods of diagnosis and treatment full of promise, to which the terms **Serum-diagnosis** and **Serum-therapy** are given. The extraordinary activity of the antitoxin in controlling the deadly toxin of tetanus may be estimated from the following facts. Taking an exceedingly active tetanus toxin, Roux added to it a quantity of serum from an immunized animal, equal to $\frac{1}{900}$ part of the toxin solution. A half cubic centimetre of the mixture containing an otherwise fatal dose of the toxin was inoculated in a guinea-pig, but the animal remained unaffected. The activity of the antitoxin is indicated by the fact that the amount of serum used was only the eighteen-hundreth part of a cubic centimetre.

The efficiency of the antitoxins of tetanus and diphtheria, either when applied to the toxins directly or injected into the animal at the same time as the toxins, is unequivocal. In the case of the respective diseases the success of treatment will depend on whether the antitoxin is administered in time to prevent the fatal action of the toxin. Observations seem to show that this can seldom be done in tetanus, as the disease has no local manifestations, and the general symptoms which proclaim it already imply the presence of a general toxic action. In diphtheria, however, the local manifestations are distinct, and there is usually time, if these are recognized soon enough, to anticipate the general toxic effects by injection of the serum. Hence the so-called **Serum-therapy** is efficient in diphtheria but not in tetanus. In regard to other diseases progress on similar lines is being made. There are, further, evidences that in man the serum of those who have passed through an attack of diphtheria, pneumonia, typhoid fever, and cholera, confers immunity in animals to the microbes concerned in these diseases. The antitoxins employed in diphtheria and tetanus are examples of antitoxic sera, while those used in pneumonia, typhoid fever, and cholera are instances of antimicrobic sera. The antistreptococcic serum of Marmorek belongs also to the latter class.

4. **Toxins and Antitoxins.**—With regard to the precise nature of these bodies much has still to be discovered. Toxins, chemically, are generally classed with the albumoses, while antitoxins are probably complex albuminoid bodies, which have been placed by some in the class of globulins. The toxin, as we have seen, is elaborated by the microbes; the antitoxin is formed within the living cells of the body. When these two bodies are brought into contact the result is the production of a compound inert towards the living tissues. A union takes place between the bodies, and all recent evidence points to this union being in most cases of a chemical nature, and not, as was at one time supposed, physiological. The toxin, in other words, is neutralized. Its toxic action disappears, but the toxin is not necessarily destroyed. In the case of diphtheria the antitoxin,

which is employed therapeutically, unites with the toxin of the diphtheria bacillus circulating in the blood, and thus prevents the latter from entering into combination with the tissues and exercising its toxic effects upon them. The intimate nature of antitoxic action is one of the most complicated problems in pathology, and although a flood of light has recently been shed upon it by Ehrlich and others, the problem still remains most complex.

5. **Theories of Immunity.**—For a full discussion of the various theories which have been advanced to explain the nature of immunity, the student is referred to the more recent bacteriological text-books. Here only two of the more important and recent need be noticed, without any attempt being made to deal with either fully. In some of the theories advanced special stress is laid on the blood-serum; in others on the cells of the tissues. The "humoral" theory is especially associated with the names of Nuttall, Behring and Buchner. These observers hold that the serum exercises a bactericidal effect, or renders the toxins of the microbes inert. This property of the blood-serum resides, according to Buchner, in certain chemical bodies called alexins. It is evident, however, that these bodies in the serum must be the product of the activity of the cells, and that it is to the cells that we have to look for an explanation. The part played by the cells is specially emphasized by Metschnikoff in his theory of phagocytosis.

Phagocytosis is a direct cellular action, and it is at least one of the modes in which the cells deal with the infective agents. Metschnikoff's first observations were made on a fungous disease of the water-flea or daphne, in which spores are visible in the transparent body of the animal. He found that when the spores were present in small numbers the amœboid leucocytes, collecting around them, took them into their substance, destroyed their power of germination, and finally disintegrated them, while if many spores were present, some of them, which were not taken up by the leucocytes, germinated and grew through the body. Thus it appeared that the active cells of the animal have the power of attacking, and in some cases englobing, the intruding organisms, which are afterwards disposed of by a process of digestion.

In the further development of this doctrine Metschnikoff recognized a difference between the leucocytes and the fixed cells of the tissues. Both may become amœboid and both have the power of taking up solid particles and digesting them. In view of this power he names them **Phagocytes** (φαγεῖν = to devour). These two forms of cells present different reactions to the various infective agents, and for the sake of distinction the polymorphonuclear leucocytes are called **Micro-**

phags, and the cells derived from the fixed cells of the tissues, which are larger and have large oval nuclei, are **Macrophags**. In all diseases of this class there is liable to be a struggle between the infective agents and the phagocytes, whether microphags or macrophags.

This process of phagocytosis undoubtedly proceeds with more or less success in many infective diseases. In erysipelas the microbe produces a severe inflammation, and the leucocytes englobe the bacteria and dispose of them. The anthrax bacillus, introduced into the frog, which is immune to this form, is taken up by the leucocytes, so that in a few hours none are free. The leucocytes convey the microbes to the liver and spleen, where they are disposed of within the cells, presenting various stages of degeneration. In other animals the number of bacilli undergoing disintegration in the spleen is in inverse proportion to the susceptibility of the animal to anthrax. Observations on relapsing fever and tuberculosis seem to show that immunity largely depends on the power of the living cells to englobe and dispose of the pathogenic microbes.

But this is not necessarily the whole explanation of natural immunity. Cells may act in other ways than by englobing, they may prevent the entrance of microbes. The layers of cells at the various surfaces of the body, cutaneous and mucous, have an important office in preventing the intrusion of microbes, and immunity to various forms of disease, such as some manifestations of tuberculosis, has probably this explanation. Cellular activity is not limited to the one mode of action.

Within recent times Ehrlich's side-chain theory is the theory which has attracted most notice and gained most adherents, and Metschnikoff has attempted very ingeniously, but not, perhaps, quite successfully, to bring his own theory of phagocytosis into line with the problems brought forward by Ehrlich.

Ehrlich's Side-chain Theory.—According to Ehrlich, the protoplasm of the cells of the body may be regarded as being built up of highly complex groups, which may be compared to the radicles of an aromatic compound. There is a more stable central group—corresponding to the benzene ring—and much less stable lateral groups or side-chains. These latter are easily acted upon by various agents, and the whole molecule is thereby changed. To continue the chemical analogy, the hydrocarbon C_6H_6 benzene is a very stable body. It can only be broken up by severe measures, and can be modified by comparatively few reagents. Whereas benzyl alcohol $C_6H_5CH_2OH$ containing an alcoholic side-chain, is easily acted on; it can be readily oxidized to benzoic acid, or the side-chain may be easily split off. When two or more groups are present as side-chains, as for instance in salicyl alcohol $C_6H_4<\begin{smallmatrix}OH & (1)\\ CH_2OH & (2)\end{smallmatrix}$, one group is usually much more easily affected than the other. In this case oxidizing agents will convert the alcohol into salicylic acid $C_6H_4<\begin{smallmatrix}OH & (1)\\ COOH & (2)\end{smallmatrix}$. The addition of a solution of sodium bicarbonate to this will change it to sodium salicylate $C_6H_4<\begin{smallmatrix}OH\\ COONa\end{smallmatrix}$, and a solution of caustic soda into di-sodium salicylate $C_6H_4<\begin{smallmatrix}ONa\\ COONa\end{smallmatrix}$. Rapid heating of salicylic acid, better with hydrochloric acid, will break off the carboxyl group and convert it into phenol and carbon dioxide. Thus the compound can be modified in various ways without affecting the benzene ring at all. With increase in the number of side-chains and greater complexity of the compound the possible modifications become greater and the susceptibility to change increased. Alkaloids and albuminoid substances, for example, are readily disorganized.

Ehrlich's theory is largely an adaptation of these chemical facts. Living protoplasm is an extremely complex substance and easily modified, but Ehrlich conceives it (for the purpose of explaining certain phenomena) to be made up of a central principal group, which he terms *Leistungskern*, and a number of lateral groups, side-chains or **receptors**. Ehrlich's groups must not be confounded with the chemical groups known to exist in albumin. Their constitution is at present quite unknown. The receptors under ordinary circumstances simply act as carriers of food-stuffs to the *Leistungskern*, but when confronted with bacterial toxins and the like, *i.e.* with bodies allied to food-stuffs, they are sometimes able to react with these.

The toxins too he believes to be made up of at least two groups. One, the more stable, he calls the **haptophorus**, another, less stable, the **toxophorus** group. When the toxin is introduced into the body the haptophorous group reacts with the receptors of the cellular protoplasm and unites the toxophorous group to the central essential part of the protoplasm. A new combination foreign to the life of the cell is thus produced, and this induces symptoms varying with the kind of cell affected and the kind of toxin used—after tetano-toxin tetanus is produced, and so forth. The receptors and haptophorous groups are very necessary parts in the reaction. Without either of them the toxophorous portion of the toxin could not be combined with the protoplasm of the cell; hence the toxin would remain inactive. This is the probable explanation of the non-toxic action of not a few bacterial products. The various groups are highly specialized. They can only interact with comparatively few other groups, some with more, some with less. A few have a very marked selective action. Tetano-toxin, for example, in guinea-pigs mainly reacts with certain groups found in nerve cells or their processes. Ehrlich, using a simile of E. Fischer, aptly compares the phenomenon to a key and a lock.

It is further supposed that very small doses of toxin, like most other poisons, stimulate the activity of the cell, and this stimulation being more or less specific results in the excessive production of receptor groups. On the analogy that a benzene ring cannot carry more than a certain number of any one radicle, these groups are believed to be thrown off into the blood, and in the blood they combine with any further doses of toxin administered. Thus a dose of toxin which would previously have induced symptoms may now fail to do so. Some of the haptophorous groups of the toxin have, so to speak, been neutralized by the cast-off receptors in the blood, and are therefore not available to interact with the receptors of the protoplasm. The toxophorous groups, as we have seen, are innocuous if they cannot be combined through the haptophorous groups and receptors with the cellular protoplasm. By careful and increasing dosage the protoplasm of the cell may be gradually stimulated to form more and more receptor groups, which, being cast off, accumulate in the blood to such an extent that after some time a dose of toxin hundreds of times greater than the normal toxic dose may be given with impunity. These cast-off receptor groups are known as **Anti-bodies**, in this case antitoxin; we have produced in fact an antitoxic serum.

The reaction on the part of the cells is by no means limited to the production of antitoxic bodies. Various other anti-bodies are known, which according to their mode of production and effect are called cytolysins, agglutinins, precipitins, etc. These only produce their specific effects in specific cases. The agglutinin obtained by injections of typhoid bacillus into an animal will almost solely clump typhoid bacilli. Of cytolysins we have hæmatolysin, hepatolysin, nephrolysin and many others, which will only disintegrate red blood-corpuscles, liver cells, and kidney epithelium respectively. These substances are produced in much the same way as antitoxins, but their mode of action is somewhat more complex. A third body termed a **Complement** (*alexin*, *cytase*) is necessary, and this seems to exist in the cells of the tissues along with the central group and receptors. The immune serum, obtained by injecting these cells into another animal, simply acts as an intermediary body or amboceptor which unites the complement to the essential protoplasm. It is in fact simply the haptophorous portion of an anti-body. The action might be compared to the effect of water on mustard. The glucoside and ferment in mustard cannot react to form volatile oil of mustard, until they are dissolved in water.

Besides bacterio-toxins there are also bacterio-lysins and other active substances, but for further information on this point, as well as for a fuller statement and examination of this important theory and its bearing upon immunity, the student is referred to recent bacteriological text-books and to the papers of Ehrlich, Welsh, Muir, and Ritchie, on the subject.

That drugs and chemical substances generally cannot produce anti-bodies Ehrlich explains by the fact that these compounds do not enter into the intimate composition of the protoplasm. Only food-stuffs and substances allied to food-stuffs (bacterial toxins, etc.) can do this, and hence these are the only bodies which can act as specific stimulants of the *Leistungskern* and induce the formation of anti-bodies.

6. **Duration of acquired and artificial immunity. Inheritance.**—It is well known that immunity acquired by passing through such a disease as scarlet fever or small-pox persists for years, or perhaps during the remainder of life. Immunity induced by vaccination is of the same nature, but it is presumably less complete and of shorter duration than that acquired from the disease itself. Immunity induced by antitoxins is of still shorter duration. In the former case the living cells are stimulated to produce antitoxin sufficient to counteract the action of the toxins, and this ability may be persistent. In the latter case the animal is mostly passive, and the immunity passes off when the antitoxin introduced is exhausted.

It is consistent with the views stated above that **Inheritance** plays a very small part in artificial immunity, whereas in natural immunity it is an element which has to be taken into account. According to the views of Ehrlich and Vaillard, the male has no influence in transmitting acquired immunity to the offspring. In the case of the female any immunity conveyed is rather that of an antitoxin than of vaccination, and is evanescent. Hence vaccination is necessary in the child, even although the parents may possess an acquired immunity.

Literature.—See fully in STERNBERG, Bacteriology, 1892; PASTEUR, Numerous papers in Comptes rendus; Report of Commission on Hydrophobia, Brit. Med. Jour., 1887; KOCH, Traum. Inf. Dis., Syd. Soc. transl., 1880; BEHRING, BRIEGER, KITASATO, EHRLICH, WASSERMANN, Many papers in Deutsch. med. Wochenschr. and Zeitschr. f. Hygiene; METSCHNIKOFF, Virch. Arch., xcvi., xcvii., cix., cxiii., Brit. Med. Jour., 1891, i., 213. Annales de l'Institut Pasteur, No. 9, 1894; L'immunité dans les Maladies Infectieuses, Paris, 1901; ROUX, Annales de l'Institut Pasteur, Nos. 9 and 10, 1894; HESS, Virch. Arch., cix., cx.; EHRLICH, Zeitschr. f. Hyg., xii., 1892; Croonian Lectures, Proc. Royal Soc., Lond., lxvi., 424; VAILLARD, Annales de l'Institut Pasteur, x., 1896; HAMILTON, On Heredity in

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III.—INFECTIVE DISEASES.

The diseases so termed have all, as we have seen, the character of infection (see page 142). The group comprises an immense number of widely differing affections, most of which are more suitably treated in the special section of this work. No attempt will here be made to give a detailed classification of the various diseases included in this category, for, with regard to many of them, our knowledge is still so imperfect that their place in any systematic classification can only be tentatively held. For purposes of convenience we shall first of all consider septic infection, which may be taken as the type of the diseases belonging to this class. A number of acute specific diseases, the microbic origin of which is in some cases proved, in others inferred, will then be passed in review, and under a separate heading a group of infective diseases in which new-formation is a more or less obvious feature (Infective Tumours) will be dealt with.

I. SEPTIC INFECTION.

It may be said that the whole of the modern activity in regard to infection has its foundation on septic infection. The terms sepsis and septic (σήπω = I putrefy) designate the contamination of the animal body with the products and agents of putrefaction. It is, of course, with microbes that we have here to do, and more especially those which, contaminating wounds, are liable to produce suppurative inflammation.

The specific forms of microbes concerned in septic infection will be considered later. Here the processes which result in the tissues will be first reviewed.

Septic infection is induced in various ways. The microbes are present in the air, in water, and on the cutaneous and mucous surfaces of the body. These surfaces are furnished with layers of cells which prevent the intrusion of infective agents, but in the case of wounds, they readily find access, and they may even without wounds be carried into mucous canals or cavities in which they are not normally present and which have not sufficient provision for their extrusion. This is the case with the urinary bladder for example. A breach of surface is therefore usually necessary for septic infection, but not always.

A *recent* wound forms the most favourable opportunity for septic infection. The interstitial spaces of the body are laid open, in the recesses of which the microbes may lodge, and there is no such blocking of the passage with new-formed cells as ultimately occurs. The larger and more intricate the spaces to which the infective agents find access, the more considerable and ineradicable is usually the infection. Hence a compound fracture in which the tissues are usually torn in a complicated fashion, if it become septic, is commonly one of the most serious of conditions.

The most direct effect of the septic invasion is acute inflammation, in which the emigration of leucocytes from the blood plays a prominent part. Hence suppuration is a feature of most septic infections, and may indeed be almost regarded as the principal local effect and criterion of such infection. Besides the inflammation, which is of greater or less intensity, there is, in many cases, a necrosis of tissue, which takes the form of a gradual solution without the production of considerable sloughs. Taking the contamination of a wound, such as a compound fracture as an example, it may be said that the complicated cavity produced, being planted with the septic microbes, becomes the seat of their rapid multiplication. This implies an abundant production of their special toxins, which again have their local and general effects. The local effect is an acute inflammation, suppurative in character. Under the influence of pressure or gravitation the pus, containing the septic agents, is liable to filter into the spaces in the loose connective tissue which forms the sheaths of muscles and the subcutaneous tissue. The suppuration extends to these spaces, and, as the dividing septa undergo solution, larger spaces or cavities are formed. It is thus that **Purulent Infiltration** may lead the way to the formation of **Abscess.** In other situations abscess may occur, as in the midst of an organ such as the brain, liver, or kidney. A gradual necrosis and accumulation of pus takes place, the septic agent having been implanted and undergoing multiplication *in situ*. It is consistent with what has been already noted in regard to inflammation that the tissues around the inflamed centre show active new-formation, chiefly by division of the fixed cells of the connective tissue. Hence a layer of granulation tissue mostly forms around the abscess. This layer of cells was under a mistaken idea, called the pyogenic membrane, as if it were the means of secreting pus. No doubt leucocytes exude from its vessels as from those of the tissues around so far as they have been affected by the toxin, but the cellular layer is really a barrier to the extension of the process, controlling the penetration of the microbes, and shutting off communicating passages in the connective tissue around. An abscess which has acquired a complete cellular membrane is thus more under control than one in which purulent infiltration is still possible.

Septic infection of serous cavities or of surfaces other than mucous has a somewhat different course to that described above. The septic agent may reach the peritoneal cavity directly from the cutaneous surface, the intestine, the genital canal in females, or the urinary organs. The pericardium may, by circuitous routes, become contaminated. The meninges may be infected directly through the skull or by indirect routes. The result is acute inflammation, going on to suppuration, but without necrosis of tissue. It is seldom that abscess formation occurs in the loose connective tissue under the serous membranes, unless as a part of the original infection to which that of the serous cavity is itself secondary. In the serous cavity there is for the most part a fibrinous exudation which goes on to suppuration. The toxin which has the power of causing solution of the connective tissue has a similar power on the fibrine, and a solution of it occurs, in some cases very rapidly, so that the more solid exudation gives place to fluid pus.

In a local septic infection, however, the blood-vessels may be involved, more particularly the thin-walled veins. The infection may extend through the wall, or it may find entrance through the severed ends of these vessels in cases of wounds or injuries. The consequence of such an extension is an inflammation of the wall of the vein, which is accompanied by coagulation of the blood, already stagnant, as a rule, in the vessel. Hence the term **Thrombo-phlebitis**, so familiar in older medical literature, means a septic and ultimately a suppurative inflammation of a vein. This condition is not now common, except in connection with the veins of the skull and meninges, arising in these regions chiefly from septic infection of the complicated structures of the middle ear. The veins of the leg, in cases of septic infection in connection with compound fracture, used to be sometimes found full of pus, and with the walls of the vessel infiltrated with pus. It was to such a condition as this that the term **Pyæmia** was given under the idea that the presence of pus in the blood-vessels was the serious and essential element. The admission of septic microbes into the veins frequently gives rise to their transportation to other parts, and the septic infection may become distributed, not in the form of a general infection of the blood, but in that of multiple infections at a distance from the primary seat. This extension occurs by a process of embolism, and the embolic obstruction does not arise merely from the microbes, in which case it would be capillary, but the softened thrombi from the veins are the obstructing agents, and as they carry with them the septic agents, they become the vehicles of infection. As the infection of the vein is the primary condition, it is the lungs which are most frequently the seat of such infective emboli, although the infective particles may extend through the lungs and be distributed by the systemic arteries. In this case the organs most frequently affected are the kidneys, but we may have also the liver, heart, intestine and other organs involved.

It will be seen that pyæmia is a septic infection in which dissemination has occurred by embolism. The result is, in every place where the septic material is implanted, the occurrence of an acute inflammation with necrosis. Fig. 46 gives a general view of such a lesion in the kidney. It is an abscess in miniature, the central parts are necrosed, as evidenced by the entire absence of nuclear staining, whilst around this is a great congregation of leucocytes. It is to such lesions at a distance from the original seat that the name **Metastatic Abscesses** is given.

It may be added that septic microbes may apparently reach the blood without the intermediation of a wound of any kind. Probably these fine particles in small numbers obtrude themselves into the vessels in the lungs and alimentary canal, but are readily disposed of as a general rule. They may, however, from exceptional local circumstances or from some special virulence in themselves, be planted in the internal structures of the body. This takes place most frequently in the bones (see Acute Osteomyelitis) and on the endocardium (see Malignant Endocarditis). In the latter case the situation is such that metastatic abscesses in the systemic circulation are peculiarly liable to occur (see Fig. 46).

Septic infection is commonly associated with extension of the toxins into the blood with the result of **Septic Intoxication** or septicæmia. The principal feature of this condition is fever. The occurrence of **Rigor** followed by febrile rise of temperature is often the signal of the establishment of a septic infection or of its further extension. The fever is not generally homogeneously continuous, but has the irregular character of hectic fever. It cannot be said to what extent this septic intoxication may be a complication of conditions, not primarily septic, such as scarlet fever, diphtheria, tuberculosis.

The septic toxin may also lead to organic change at the seat of its excretion. It seems probable that the somewhat frequent inflammation of the kidneys in tuberculosis and scarlet fever is due to this cause.

Pyogenic Microbes.—This is the name given to the microbes of acute inflammations tending to suppuration. The microbes are pyogenic, or producers of pus. The majority of the bacteria in this

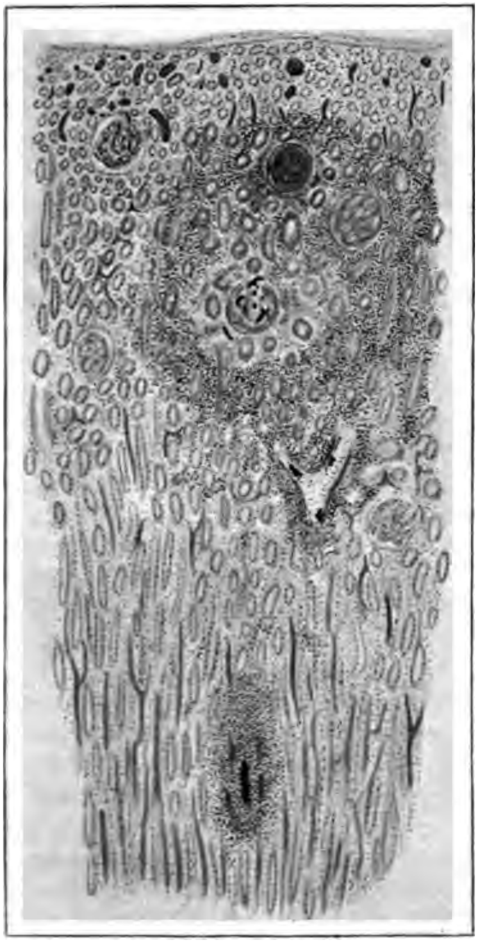

Fig. 46.—Embolic abscesses in kidney from a case of ulcerative endocarditis. In the larger abscess the necrosed central part surrounded by an area of round-celled infiltration is shown. In several of the smaller vessels microbic emboli are seen. × 40.

oup are micrococci and, on the other hand, most of the pathogenic crococci belong to this group. The toxin of the microbes is, accord- g to Buchner, a proteid substance which is present in the bacteria mselves. This substance produces suppuration apart from the crobes, and it does not lose its virulence even when heated for rs to 120° C.

The more common pyogenic micrococci are *staphylococcus pyogenes aureus*, *albus* and *citreus*, *staphylococcus cereus albus* and *cereus flavus*, *streptococcus pyogenes*, *gonococcus*, *micrococcus tetragenus*, *pneumococcus* (see under pneumonia), *diplococcus intracellularis menigitidis* (see under meningitis). Among the pyogenic bacilli are included *bacillus coli communis*, *bacillus pyocyaneus*, and *pneumobacillus* (see under pneumonia). Sometimes organisms under certain conditions produce suppuration, *e.g.* *bacillus typhosus*, *bacillus mallei*, *streptothrix actinomyces*.

1. **Staphylococcus pyogenes aureus.**—Micrococci are to be found virtually in all abscesses or suppurations, and the form now under consideration is the most important. It has been studied by many authors, of whom Ogston, who suggested the term staphylococcus (from σταφυλή, a bunch of grapes), and Rosenbach, who gave the full name, may be mentioned.

It is smaller than the coccus of erysipelas, and in its growth tends to form little masses rather than chains (Fig. 47). It is not known to produce spores, but it is peculiarly resistant to drying and heat. It may be kept dry on a cover glass for ten days without losing its power, and it requires the temperature of boiling water for several minutes in order to kill it.

It grows at the ordinary temperature, but more vigorously at higher temperatures. It grows on gelatine, agar, and potato, forming in all of them bright orange-coloured masses from which it derives its name. These have been aptly compared to layers of oil paint. It rapidly liquefies gelatine.

Suppurative inflammations have been frequently produced by the artificial application of this bacterium. Garré applied it to his own person, once to a fissure at the finger-nail, and once by rubbing into his forearm. In the former case he produced a spreading suppuration, and in the latter a considerable carbuncle, which took weeks to heal.

The relation of this microbe to acute osteomyelitis and to ulcerative endocarditis is very interesting. If large quantities of the culture be injected into animals they will die of poisoning in a short time, but if small quantities be used they usually recover. However, an injury to the valves of the heart on the one hand, or to a bone on the other, will determine the settlement of the cocci in one or other of these situations, the result being a malignant infective inflammation. (See under Acute Osteomyelitis, and Ulcerative Endocarditis.)

Abscesses may be produced in animals by the subcutaneous injection of cultures of this microbe. Acute peritonitis is produced by injection into the abdomen, and acute synovitis by injection into the joints.

This micrococcus is very widely distributed, occurring in almost all suppurations, but also in the normal saliva, in water, and air. All open wounds are exposed to its inroads, and it will depend somewhat on circumstances whether it penetrate further inwards.

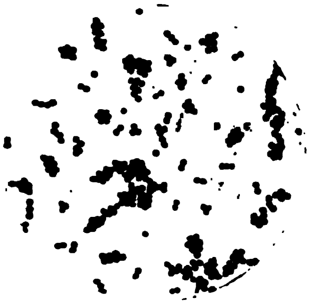

Fig. 47.—Staphylococcus pyogenes aureus. × about 1000.

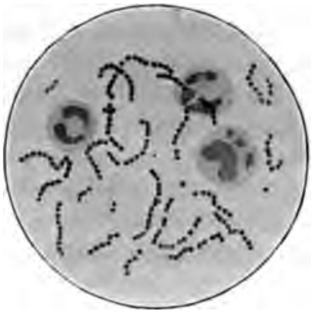

Fig. 48.—Streptococcus pyogenes. × about 1000.

2. **Staphylococcus pyogenes albus** closely resembles, and is probably a variety of, that just described, almost the only difference being that, when growing, it does not produce a yellow pigment, but instead, a thick white layer. It is less common than the yellow form, and apparently less malignant. The **Staphylococcus pyogenes citreus** shows cultures of a lemon-yellow colour. It is less common and less virulent than either of the above mentioned. The Staphylococcus cereus albus and flavus are of much less consequence; they produce white and yellow wax-like cultures respectively.

3. **Streptococcus pyogenes** is not infrequently found in pus (Fig. 48), either alone or in conjunction with the Staphylococcus aureus. In all its characters it closely corresponds with the streptococcus of erysipelas, having a similar mode of growth on nutrient media, and is now generally regarded as identical with it (see Erysipelas).

4. **Micrococcus gonorrhœæ, Gonococcus.**—This form, discovered by Neisser, is now acknowledged to be the active agent in the causation of gonorrhœa. It is a large micrococcus, which is generally found united in twos (diplococcus), the two surfaces facing each other being usually concave. The gonococcus cannot be detected by Gram's method, as the iodine decolorizes it. It may be stained by the ordinary aniline dyes.

The principal peculiarity of the gonococcus is that it is found in the substance of the pus cells (Fig. 49), often filling the protoplasm but leaving the nucleus free. It is exceedingly difficult to cultivate, success having been obtained by the use of human blood serum, and other media, but the growth has been comparatively slight. The identity of the coccus and its connection with gonorrhœa was proved by Bumm, who inoculated a culture of the third generation in the female urethra, and produced a typical gonorrhœa in three days. In certain animals, especially in white mice and guinea-pigs, inoculation of the abdominal cavity produces a suppurative peritonitis.

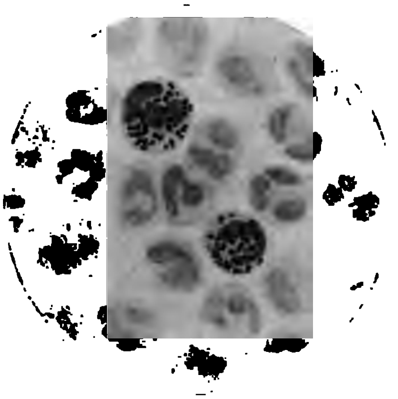

Fig. 49.—Gonococcus. Two pus corpuscles are seen whose protoplasm is filled with diplococci. The nuclei are at one side. From a case of gonorrhœal ophthalmia. × about 800.

5. **Micrococcus tetragenus.**—This microbe was discovered in the contents of a tubercular cavity in the lungs, and afterwards in normal sputum. It has been found in suppurations in the neck, in pulmonary abscesses, etc., and may occur alone or in association with other microbes. It has been investigated by Gaffky. It consists of micrococci, which, when found in the living body, are arranged in fours, each group having a clear **capsule** around it. These groups somewhat resemble sarcinæ. The bacteria have been cultivated in nutrient media, but they lose their peculiar arrangement. They have been used for inoculation in animals, and are violently pathogenic in white mice and guinea-pigs, while house and field mice and rabbits are insusceptible. The cocci are found in the blood and tissues of all organs. This microbe may be the cause of pathological conditions in man, especially suppurations.

6. **Bacillus coli communis.**—This bacillus is constantly present in the colon of man and frequently in the fæces. It is also sometimes present in the vagina and uterus, and may be the cause of peritonitis by extension from these organs, as in cases of puerperal fever and of Cæsarian section. It is a short rod, closely resembling the bacillus of typhoid fever (see Typhoid fever), and it possesses powers of movement due to cilia which are sometimes single, and sometimes multiple. They are situated at the sides of the bacilli. It grows on the usual culture media in the presence of oxygen (see Fig. 50).

This bacillus is obviously non-pathogenic in the intestinal canal, but it is highly pathogenic in the peritoneum. It has been found as a pure culture in peritonitis resulting from perforation of the intestine.

Inoculation of cultures into the peritoneum of rabbits produces an acute peritonitis. The disease is much more severe when cultures have been made from the peritoneal exudation in cases of perforation of the intestine in man, than from the contents of the intestine. Similar intensified cultures are obtainable from the intestine of animals by artificially obstructing the intestine.

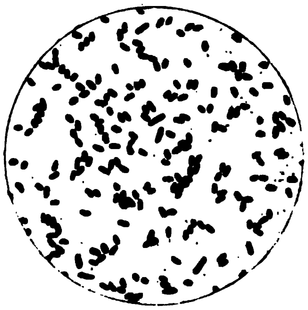

Fig. 50.—Bacillus coli communis. × about 1000.

Adami finds the bacillus coli in the liver in many cases, and it presents various transformations, appearing sometimes as a diplococcus. He suggests that the liver has a bactericidal power on this bacillus, and possibly other bacilli, absorbed from the intestine. He has found these polymorphic forms especially in cirrhosis, and suggests that the bacillus coli may take part in the causation of that disease.

7. **Bacillus pyocyaneus (Bacillus of blue or green pus).**—Surgeons sometimes find that the dressings suddenly assume a bright green or blue colour, which may occur without disturbing the process of healing. This is due to a small bacillus which has found access to the secretions of the wound, and has multiplied there. It is a slender rod, often united in small chains of four to six cells. It has very lively movements; no formation of spores has been observed. It has been cultivated in various nutrient media, the culture usually giving a greenish colour. The pigment has been extracted by chloroform, and separated as long needles. It has been observed also in the pus of cases in which the dressings have been stained. This pigment is named by Gessard pyocyanin. This form of bacterium produces in certain animals, especially rabbits and guinea-pigs, suppurative inflammation. In man it is only occasionally pathogenic.

II. ACUTE SPECIFIC DISEASES.

In some of the diseases to be mentioned in this group the presence of an infective agent is presumed, in others it is definitely determined.

A. **Acute specific diseases of uncertain microbic origin.**—Here will be considered the group of **acute specific fevers**, and along with these will be included some allied affections, whose precise nature is as yet unknown. The acute specific fevers are, for the most part, infectious. In the great majority of cases, they also present a distinct periodicity, that is to say, they tend to come to a spontaneous termination at the expiry of a certain number of days or hours. This, as we have seen, is in most cases to be referred to the production in the course of the disease of an antitoxin which by counteracting the toxin brings the disease to a termination. But this explanation does not apply to the periodicity of the malarial fevers, in which the life history of the parasite determines the peculiar periodicity of the attacks, and it may be so in regard to some other forms. With these exceptions we may associate the fact that, in most of the forms of disease under consideration, immunity is acquired by a single attack of the disease.

In regard to the specific fevers the relation of the infective agents to the phenomena of the disease is various. As the effects in all the forms have the common feature of fever, it may be inferred that the blood is the vehicle by which the agent which directly produces the symptoms is conveyed. But as the actual symptoms are those of intoxication, it may be inferred that the infective agent, the parasite, need not itself be present in the blood, but that it is sufficient if the toxins produced reach that vehicle. Hence we may distinguish two categories, although the distinction is not an absolute one. There are diseases of this group in which the infective agent is present in the blood, and there are others in which the infection is localized, and only the toxins reach the blood. Even with this division a further distinction has to be made, as the infective agent may at a certain stage be present in the blood, or may be conveyed by it, whilst it may subsequently be deposited locally and produce an intoxication from its more local seat.

Keeping these facts in view, the principal specific febrile diseases may now be briefly reviewed.

1. **Small-pox. Variola.**—This disease has two febrile periods, which, it may be inferred, have different relations to the infective agent. There is the primary fever which is accompanied by severe general symptoms, and is probably to be explained by the presence of the infective agent and its toxins in the blood. It is not a mere matter of inference that the agent is in the blood, as its subsequent presence in the skin all over the body can only be explained by its being carried by the blood. The secondary fever coincides with the appearance and development of the eruption in the skin. The infective agent, which is probably a protozoon, multiplies in the epidermic layer of the skin, and the fluid or lymph which is there produced is highly infectious. As the eruption occurs only in the skin and mucous membranes immediately continuous with it, such as the mouth and extreme lower extremity of the rectum, we may infer that oxygen is required by the

contagium for its development. It is probable that the local multiplication in the skin is associated with the production of toxins, which passing into the blood produce the secondary fever and other general symptoms. The suggestion that the secondary fever is septic is not a tenable one, as the fever occurs where the eruption has not yet produced any breach of surface, and where no septic microbes are present in the lymph.

The nature of the infective agent in small-pox and vaccinia has been the subject of much investigation and discussion. The lymph from the characteristic pustules is undoubtedly the vehicle of contagion, and it contains multitudes of minute particles. The pustules themselves contain peculiar bodies which are largely within the epidermic cells at first, but, as the cells are destroyed, become free. Inoculation has been successfully performed, chiefly on the cornea of the rabbit, and here also peculiar bodies are found in the epidermic cells. These bodies, which are in a non-committal style, called "vaccine-bodies" or "variola-bodies," are of various sizes, and are rendered prominently visible by various methods of staining. Their nature is matter of serious difference of opinion. On the one hand they are accepted as parasitic, and if so they are protozoa. By those who accept this position the name cytoryctes vacciniæ Guarnieri is adopted for the parasite, Guarnieri being the author of the first reliable research on the subject. Those opposed to the parasitic view, while acknowledging the actuality of the bodies, regard them as products of the nuclei or protoplasm of the epidermic cells. A late writer on the subject, whilst denying that these bodies are parasites, yet holds that they are the product of the contagium, and that the true infective agent develops and multiplies in the epidermic cells, and more particularly in these bodies which he regards as derived from the protoplasm. The matter is, therefore, still *sub judice*, but seems on the way to decision.

2. **Chicken-pox. Varicella.**—Here the infective agent is equally unknown. Various forms of bacteria have been described as occurring in the vesicles, and bodies resembling those met with in small-pox have also been found.

3. **Scarlet Fever.**—The relations of the local lesions and general symptoms to the infective agent are, in this disease, obscure and complicated, and are not likely to be cleared up till the infective agent itself is discovered. As yet no form of microbe has been conclusively demonstrated as the causative agent in scarlet fever. There are two pronounced seats of local lesion, the fauces and the skin. In the former, which is presumably the primary seat, an acute inflammation, usually with necrosis, is present, and the process is sometimes severe and

destructive (Scarlatina anginosa). In the skin the lesion is an acute inflammation usually little more than an active congestion, so that the skin presents little change when examined after death. The infective agent is undoubtedly present in the fauces, and there can be little doubt also that it passes into the blood. The lesion in the skin might be the result of the action of toxins, but the subsequent infective nature of the desquamated epidermis (which, however, some observers question) would indicate that the infective agent is present in the blood and carried to the skin. Sometimes the symptoms point to a high degree of intoxication, so that, with very little local lesion, there may be a very severe attack, fatal in a few days. These cases are scarcely explicable except on the supposition of an agent multiplying with great vigour in the blood. To the local lesions may be added that of the kidney (see under Diseases of the Kidney), which is presumably due to the toxin. It consists in an inflammation, concentrated on the glomeruli in the early stages of the fever, but affecting the whole secreting structures in many cases. This affection of the kidneys may lay the basis for Bright's Disease. The local affection in the throat is often the seat of invasion by the ordinary septic microbes, more particularly the streptococcus pyogenes. It cannot as yet be determined how far the local lesion may be due to this invasion or to the primary agent, nor can it be stated how far the general symptoms, and even the local lesions in the kidneys, are due to septic intoxication. It is a case of mixed infection. The great destruction of tissue, involving in some cases the structures of the middle ear, point either to a special virulence in the infective agent, or to an extreme degree of potency in the mixed infection.

4. **Measles.**—In the absence of any knowledge of the infective agent, we are in this disease, as in the case of scarlet fever, left to inference as to the principal seat and mode of action of the infection. The infection is volatile, and it seems specially virulent in the early stages of the disease. The local symptoms consist mainly in catarrhal inflammation of the mucous membranes of the nasal and respiratory passages, often going on to inflammation of the lungs, and in an eruption in the skin which is also inflammatory. There is more than a simple congestion as in scarlet fever, so that after death infiltration of leucocytes is visible, especially around the sebaceous and sweat glands. There may also be small hæmorrhages. Whether the infective agent remains localized in the respiratory tract, and only the toxins are present in the blood, or whether the infection itself reaches the blood, is unknown.

In **German Measles** or **Rubella** we may presume a less active infective agent is present.

5. **Typhus Fever.**—Here also we are, as yet, in the dark as to the form of the infective agent. It is volatile, as infection occurs through the air, by inhalation. It is to be inferred that the infective agent is present and multiplies in the blood. There is no constant local lesion. The red blood-corpuscles show very striking changes in shape and indications of disintegration. The eruption in the skin is rather in the form of a passive hyperæmia, with disintegration of the blood so as to stain the tissues, than of a true inflammation. Hence it partly persists after death as stains or blotches. The skin may show evidences of a more considerable disintegration of the blood in the form of a general staining almost amounting to jaundice.

6. **Yellow Fever.**—The general aspects of this disease resemble those of typhus fever. There is no local lesion, and there is a profound alteration of the blood. The blood-corpuscles are so much destroyed that their hæmoglobin stains the liquor sanguinis, and by means of this the skin and other tissues. It is from this coloration that the term yellow fever is derived. Sanarelli claims that the bacillus found and named by him **Bacillus icteroides** is the cause of yellow fever. His results have, however, not been confirmed by recent observers. The United States Army Commission, recently appointed to enquire into the etiology of yellow fever, have brought forward a number of most important results. They have shown not only that the blood of a patient suffering from yellow fever if injected into a healthy person will induce the disease, but that the diluted and filtered serum will do the same. They have proved further that the mosquito may be a means of transmitting the disease from one person to another, but what the nature of the virus so transmitted is remains still to be determined.

7. **Whooping Cough.**—The infective agent in this disease is quite unknown, although many attempts have been made to discover it. The indications are that it lodges in the respiratory passages, where its toxin produces irritation resulting in catarrh and the violent paroxysmal coughing which characterizes the disease. It is probable that there is not from the pure infection much general intoxication. There is frequently, beyond a simple catarrh, a serious broncho-pneumonia which greatly raises the mortality of whooping cough. But whether this is the result of the direct infection or of a secondary infection of the ordinary pyogenic microbes remains as yet obscure.

8. **Mumps. Contagious Parotitis.**—This is one of the milder specific fevers in which the nature of the infective agent is also unknown. It occurs usually in epidemics, and is highly contagious. The salivary glands are the seat of an inflammatory swelling which rarely ends in

suppuration, but subsides in a short time, leaving the gland uninjured. Secondary inflammatory manifestations—the so-called metastases—are frequent in the testicle, mammæ, etc. They may in the testicle lead to atrophy. Meningitis has been observed to supervene in not a few cases.

9. **Rheumatic Fever.**—This is a disease whose right to a position amongst the infectious may still be disputed by some, and which has, in the past, been regarded variously as an intoxication arising from faults of excretion, or of some nervous origin. The general aspects of the disease are those of a specific fever due to a general intoxication, and the local manifestations also point to the general distribution by the blood of a poison which has, as is usual with poisons, certain local affinities. The painful affection of the joints, which is such a prominent symptom as to give very much of its character to the disease, is not to be regarded as indicating that the primary seat is in, or in the neighbourhood of, the joints. No infective agent is known, and there is no such local centre as exists in diphtheria, typhoid fever, and other forms, in which it may be supposed that the infection has its seat. It is probable, therefore, that it is present in the blood, but it cannot be said whether it is deposited in the various local lesions or not. The disease is not infectious from person to person, nor is its mode of propagation known, but there are interesting facts showing connection with particular localities, and also its prevalence amongst the inmates of particular houses. Whilst there are the symptoms of a general intoxication, there are also local inflammations affecting chiefly certain fibrous membranes. In the localities affected the appearances indicate that, besides the direct influence of the toxic substance, friction plays a part in the production of the inflammation. Thus the localities themselves, namely, the joints, the pericardium, and the valves of the heart, are exposed to constant friction from the movements of the body, and further, in the valves of the heart, the lesion is in a striking manner restricted to those parts which are exposed to impact of neighbouring portions during the closure of the valves (see under Acute Endocarditis).

There may be a mixed infection in this disease. The regular and extended distribution of the lesion in acute endocarditis indicates the action of a dissolved toxin, or a very abundant infective agent in the blood. On the other hand, pyogenic microbes may, taking advantage of a breach of surface, attach themselves to a particular part of a valve, but this need not be in a portion exposed to friction, and it may occur when the fever has completely subsided (see under Ulcerative Endocarditis).

Recently Poynton and Paine have found in all the cases examined by them that a small diplococcus described by Triboulet and others is present in the blood of patients suffering from acute rheumatism, and may be obtained after death in all the important lesions. They were able to cultivate the organism and induce by intravenous injection in rabbits joint affections, endocarditis and pericarditis.

10. **Dengue.**—This is a specific infectious fever of tropical countries. As in rheumatic fever severe pains in and around the joints are common, and as in scarlet fever and measles, erythematous and roseolar eruptions are almost constantly present. The sudden onset, brief duration, and low mortality are all features in this disease. The nature of the infective agent is quite unknown. We may infer that warmth is evidently essential to its life outside of the body, for it is found that dengue at once dies down in a community whenever the temperature falls below a certain point.

11. **Rabies. Hydrophobia.**—Will be dealt with under Diseases of the Nervous System.

B. **Acute specific diseases of certain microbic origin.**—Many of the diseases included under this heading are more satisfactorily dealt with elsewhere. This is particularly the case with regard to such diseases as *Acute Pneumonia*, *Diphtheria*, *Typhoid Fever*, *Cholera*, *Tetanus*, *Epidemic cerebro-spinal meningitis*, *Infective endocarditis*, etc., notice of which will be taken in the special part of this work. A certain number of allied diseases may here be more conveniently passed in review.

1. **Erysipelas.**—The micrococcus of erysipelas, **Streptococcus erysipelatis**, is composed of perfectly globular cells of small size, which have a peculiar tendency to grow into long chains. It has been cultivated on various media, growing slowly at the ordinary temperature, and more quickly when the temperature approaches that of the body. The cocci grow most abundantly in bouillon, and as a rule no visible growth takes place on potato. In growing they form little white colonies of circular outline which have a characteristic appearance, and do not liquefy gelatine. As we have seen, these are the characters of the streptococcus pyogenes (see p. 159).

In cases of erysipelas they are found in the lymphatic spaces and vessels, which they frequently fill out so as to form a kind of injection of them. They do not extend beyond these vessels, but their poisonous products not only produce intense local inflammation, but, passing to the blood, cause fever and other general symptoms. The bacteria are scarcely at all present in the inflamed area, but are abundant at the margins. The cocci evidently produce their toxin, and subsequently perish, leaving the poison behind.

Erysipelas is producible artificially by inoculation of cultures of this streptococcus. The most convenient experiment is to inoculate the ear of a rabbit; this leads to an acute inflammation, which terminates in from six to ten days without suppuration. Mice are immune to this microbe. Fehleisen has successfully practised inoculations in man with a view to treatment of tumours.

In ordinary cases of erysipelas the bacteria are usually derived from the air, but may be conveyed by contact. The point of entrance is probably in all cases a wound; it may be a very trivial one.

2. **Influenza.**—In cases of epidemic influenza the microbe—**Bacillus Influenzæ**—is found in the mucus discharged, and it is more pure the further down the bronchial tree the discharge has been produced. In cases of death pure cultures have been found in the fine bronchi as well as in the lung alveoli, when catarrhal pneumonia is present. In the febrile stage the bacilli are mostly free, but during convalescence they are chiefly in the substance of leucocytes. The bacilli have been found in small numbers in the blood and occasionally in the exudation of the meningitis, which sometimes complicates influenza.

The bacillus is a very small, short, thin, non-motile rod. It is stained by the ordinary dyes but not by Gram's method.

Cultures are best made on blood-agar, on which the growth forms minute transparent drop-like colonies in about twenty-four hours. The cultures require a temperature of 26° to 42° C., and die down readily.

Animals are mostly refractory to the bacillus. Monkeys have been found to a certain extent susceptible, when cultures have been injected into the trachea. The toxin produces marked symptoms of poisoning in the rabbit, especially when the bacilli are injected directly into the brain.

3. **Bubonic Plague.**—The plague used to occur in gigantic epidemics in Europe, but till lately had been banished for many years. Its recent appearance in Hong-Kong, in India, and nearer home, shows that it has lost none of its old virulence. Three forms or types of the disease are recognized, the **Bubonic**, the **Pulmonary,** and the **Septicæmic**. These may be associated together. The two first are the most important, the **Bubonic** type being the most notable. It is characterized by the appearance of lymphatic glandular swelling, usually single at first and mostly in the groin. The bubo grows quickly and the patient generally dies, usually in two or three days, often with symptoms of septicæmia. Hæmorrhage and necrosis are frequent in affected glands; suppuration is rare. Bacilli are present in enormous numbers in the early stages, but may disappear entirely from the glands in the later. Splenic enlargement and cloudy swelling of the liver and

kidney are common. Where extension has occurred to the blood, bacilli are often found in large numbers in the spleen. In the **pulmonary** form broncho-pneumonic patches with hæmorrhage are found often involving considerable tracts of lung tissue. In the lesions and in the sputum, bacilli may be readily recognized. In the **septicæmic** form glandular enlargement is usually slight, and the disease is commonly rapidly fatal. During epidemics rats and mice are affected and die in large numbers.

The **Bacillus pestis** is short and thick with rounded ends, exhibiting bipolar-staining, *i.e.* staining at each end and leaving a clear middle part. Spores have not been found nor definite evidences of motility. It is readily stained by the ordinary aniline dyes but not by Gram's method. Sometimes the bacillus has a capsule. Involution forms are common. Cultures are readily made on agar, gelatine, bouillon, etc. Inoculated into guinea-pigs, rats, and mice, it kills in a few days, and the bacilli are found in the lymphatic glands and in the blood.

4. **Malta Fever** (Rock Fever of Gibraltar) is a long-continued but seldom fatal endemic fever met with mainly but not exclusively along the Mediterranean coast. It is characterized chiefly by profuse perspiration, constipation, rheumatic or neuralgic pains, with swelling of joints, orchitis, enlargement and tenderness of the spleen. The changes found *post-mortem* are principally the result of the fever. Enlargement and softening of the spleen is usually the most striking feature.

The disease is due to a microbe—the **Micrococcus melitensis**—first described by Bruce in 1887. It is a small rounded or ovoid organism arranged singly or in pairs. In cultures short chains are sometimes seen. It stains with the ordinary dyes, but is decolorized by Gram's method. It is one of the few micrococci in which flagella have been demonstrated. The organism is found mainly in the spleen, but has been observed also in the blood after death. It is readily cultivated, showing in the course of two or three days small circular somewhat transparent whitish colonies. The serum of patients suffering from the disease possesses the power of agglutinating the micrococcus, in a manner similar to what occurs in typhoid fever.

5. **Anthrax.**—The bacillus of anthrax—Bacillus anthracis—is one of the best known and most widely diffused pathogenic forms, occurring, as it does, both as a saprophyte and a parasite. As a parasite it gives rise to the conditions variously known as **Splenic fever, Anthrax, Charbon, Malignant pustule** and **Wool-sorter's disease,** and it is sometimes described under the name Bactéride du charbon. It mostly occurs in animals, but is occasionally communicated to man.

The bacteria are rods of considerable size, generally united end to end so as to form longer threads. Each bacillus is about as long as the diameter of a red blood-corpuscle. As seen in the blood the extremities of the bacilli are abrupt, and even slightly concave, so that when two are united there is an oval space which is very characteristic.

The bacillus is capable of living on so many different media and at such different temperatures that its saprophytic forms are of great importance. It may be cultivated in many different nutrient media, nutrient gelatine, agar, potato, etc. It grows readily in neutralized or weakly alkaline urine, and in infusions of animal substances in general. On potato it grows very vigorously, forming a dry yellowish creamy layer.

In the animal body it only occurs in the form of the bacilli, which are either single or form short threads of two or three. When grown on the surface of nutrient media so as to be exposed to the oxygen of the air, the bacilli grow out into **long threads** which at first sight appear to be continuous, but when properly displayed are seen to be composed of individual bacilli. The threads form parallel groups or more tangled and matted masses. In these threads the **formation of spores** occurs when the circumstances are favourable. This requires the free access of oxygen, and a temperature between 18° and 40° C., while that between 20° and 25° C. gives the best results. The optimum temperature is between 28° and 37° C. The spore lies in the middle of the bacillus as a glancing refractive body. The bacillus by and by disappears, leaving the spore free. The spores contrast with the bacilli in being very permanent, as they resist drying and decomposition. Pieces of silk thread impregnated with spores from a culture on potato may be kept for years perfectly capable of germination.

The anthrax bacillus, like some others, requires careful staining, but if due care be taken a watery solution of almost any aniline dye may be made to serve, or Gram's method may be used for double staining. The spores are more difficult to stain. If a cover-glass preparation be first made, then it may be floated for about twenty minutes on the suface of a hot alcoholic solution of fuchsine, decolorized in weak hydrochloric acid and again stained with methylene-blue. The bacilli are stained blue and the spores red.

The anthrax bacillus is capable of transmission to a large number of animals, although considerable differences in susceptibility exist. Mice are the most readily infected, and next to them stand guinea-pigs, rabbits, sheep, and cattle. Rats are with difficulty affected, and dogs, birds, and frogs are scarcely susceptible. Frogs may be affected if after inoculation they are kept for a few days at the temperature of the incubator. Man, although susceptible, exhibits a certain degree of resistance to anthrax infection, evidenced by the fact that there is not infrequently after inoculation a local disease (malignant pustule), the bacilli being present in the exudation of the pustule.

The disease may be induced experimentally either by inoculation into the skin or mucous membranes or by introduction into the alimentary canal. For inoculation, the blood of an animal which has died of anthrax or an artificial culture may be used. In the case of the alimentary canal, cultures containing spores must be used, as the bacilli are destroyed by the gastric juice. When an animal is infected it shows the symptoms of an acute specific fever, which usually proves fatal in a few days. The bacilli are found in enormous numbers in the blood, and as a rule they are found only inside the blood-vessels. So abundant are they in some cases that a preparation stained in the proper way so as to render the bacilli prominent appears as if the vessels were injected with a coloured material. (See Figs. 47 and 48.) It is chiefly in the capillaries that they are to be found, and they are most readily observed in the spleen, the villi of the intestine, and the glomeruli of the kidney. In the latter situation there is not infrequently rupture of the glomeruli and the passage of blood and bacilli into the uriniferous tubules.

Spontaneous infection with anthrax occurs in animals mostly with their food. It originates chiefly in cattle and sheep, and they acquire it in grazing. There are certain parts of the country where the disease is endemic, the grass apparently containing the microbe. As this infection is by the alimentary canal it is necessary that spores should be present. The bacillus grows on many sorts of vegetable and animal matter on which it may be planted by the blood or discharges of infected animals. Hence the bodies of such animals should, where possible, be buried without opening and, at any rate, precautions taken against contaminating the ground with blood or tissues.

In man the disease has mostly been communicated by handling the tissues of animals which have been affected. Sometimes spore-formation will occur in such tissues, the bacilli growing on the tissue when exposed to the air and producing spores. Hence spores may adhere to hair, wool, or other material, and be conveyed long distances. Most cases in man have occurred amongst workers in hair or wool, hence the name of **Wool-sorter's disease**. In several cases occurring in Glasgow the hair had come from Russia.

When inoculation occurs by a scratch or wound of **the skin** in man, or by the pricking of **insects** which have been in contact with the blood of an affected animal, a local disease results, the **Malignant Pustule.** A small elevated boil forms of a red or yellow colour, which soon acquires a crust. The pustule has the usual characters of an acute inflammation, the cutis being infiltrated with leucocytes. There are numerous bacilli in the superficial layers of the cutis. There may be around the pustule much œdematous swelling. The infection sometimes passes on to the blood and produces the regular splenic fever.

In the **Intestinal canal** local lesions are produced similar to those of the skin. They are rare in the human subject, though common in animals. They are seated mostly in the small intestine, and rarely in the stomach or colon. Infection also occurs by **the lungs** from inhalation of spores. This has been observed amongst rag-pickers in paper works, the disease manifesting itself as an acute inflammation, affecting bronchi, lungs, and pleura. Swollen, often hæmorrhagic patches, surrounded by œdema, are found in the mucous membrane of the larger bronchi and the lower end of the trachea. Occasionally necrosis of these is seen. The adjoining bronchial glands are often greatly enlarged.

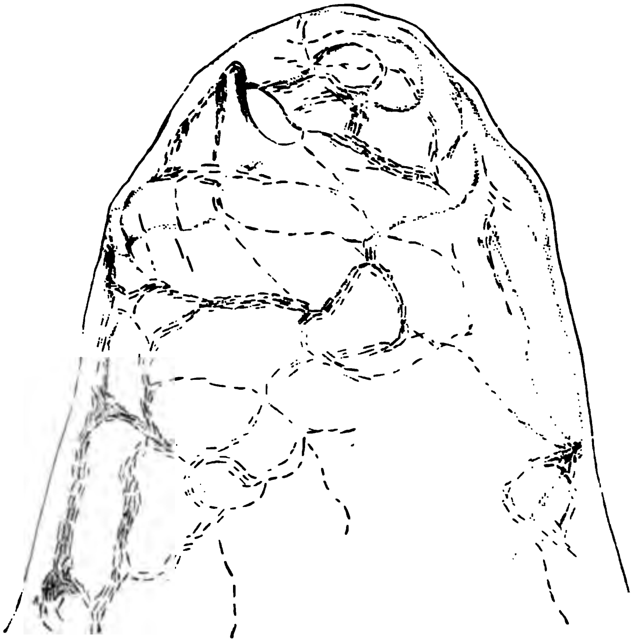

Fig. 51. Villus of intestine in anthrax, the bacilli visible as minute threads. × 250. (Koch.)

Attenuation of the virus was first attempted by Pasteur, and was attended by very striking results. By cultivating the bacillus at a temperature of 42°–43° C. for about twenty-four days, the infective power is destroyed, while a shorter period suffices to weaken it. By this means a permanent **Vaccine** is procurable. Immunity has also been procured by using a toxalbumin separated from anthrax cultures, and also, according to Wooldridge, by using a form of fibrinogen obtained from the normal blood.

When animals are vaccinated with the attenuated virus they have a mild form of the disease and acquire a certain degree of immunity to the more severe forms. The practical importance of this fact is seriously diminished because the immunity appears to be only from infection by inoculation, and does not extend to infection by taking the spores into the alimentary canal. The latter is, moreover, the most frequent mode of infection in spontaneous anthrax.

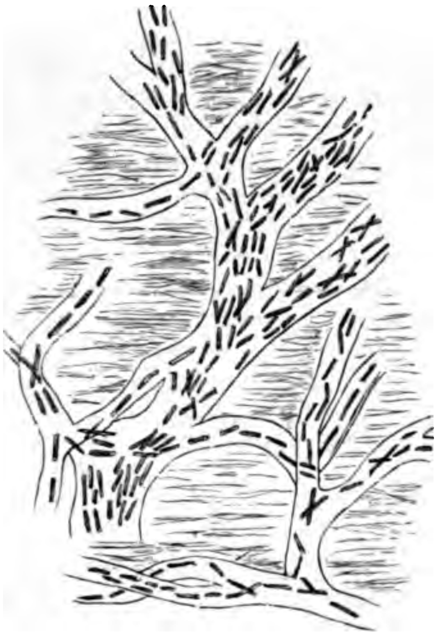
Fig. 52.—From same preparation as Fig. 51, more highly magnified. The bacilli visible as definite rods. × 700. (Koch.)

Symptomatic anthrax. — The bacillus of symptomatic anthrax (*Bacillus of "Quarter evil"; Bacillus of Rauschbrand*) is found in certain cases of disease in cattle, having a rapid course and nearly always a fatal issue. The disease has several names, such as "Black-leg," "Quarter evil," and in Germany "Rausch-brand."

The bacilli are thickish rods, which are mostly single. They have lively motion by means of numerous cilia. The bacillus grows readily on ordinary media, but it is strictly **anaërobic**. It produces spores which are thicker than the bacillus and lie nearer one end than the other, so that a somewhat club-shaped form is produced. It produces gas in stab-cultures, and is decolorized when treated by Gram's method, in both these respects contrasting with bacillus anthracis.

The bacillus is pathogenic in cattle, sheep, goats, and guinea-pigs. No case has been observed in the human subject. Guinea-pigs, sheep, and cattle have been rendered immune by inoculation of a virus of diminished intensity.

6. **Malignant œdema.**—The bacillus of malignant œdema is a bacterium somewhat similar in size to the bacillus anthracis, and it is also identical with Pasteur's "vibrions septiques" which he found in his "septicæmie." (See Fig. 53.)

Malignant œdema has been observed in man after infection of severe wounds, compound fractures, etc., by the bacillus. There is a cutaneous emphysema, decomposition, and œdematous swelling of the superficial muscles, and death generally results in a few days. The author met with bacilli closely resembling this form in a case of cancrum oris.

The bacillus is a slender rod, somewhat thinner than the anthrax bacillus and with rounded ends. It tends to grow into long threads even in the body, and it is slightly motile by means of cilia. The bacilli are **strictly anaërobic**, so that they can only be cultivated by taking precautions to exclude the oxygen of the air, as in an atmosphere of hydrogen, or by a stab-culture deeply into a solid culture-medium. In growing the bacillus evolves gas and produces a putrid odour. It is decolorized by Gram's method. It bears spores in the middle of the rods. The source of the bacilli in experimental observations is various kinds of decomposing matters, dust, garden earth, etc., and they are evidently widely dispersed.

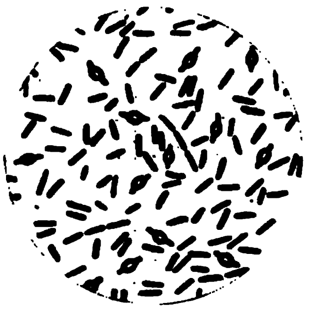

Fig. 53.—Bacillus of malignant œdema. × about 1000.

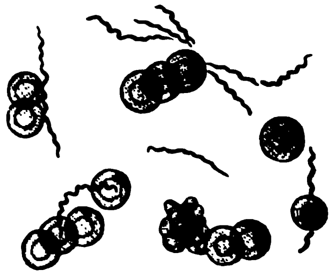

Fig. 54.—Blood from case of relapsing fever, showing corpuscles and Spirillum Obermeieri. × 750. (CARTER.)

The bacilli produce disease when inoculated in mice, guinea-pigs, rabbits, etc., and this occurs whether their source be such external matters as garden earth, or pure cultivations. Death usually results in twenty-four to forty-eight hours. Around the point of inoculation the subcutaneous tissue and superficial muscles are infiltrated with a dirty red stinking fluid in which are bubbles of gas. The bacilli are found in the œdematous fluid; none are visible in the blood. The bacilli, in fact, remain in the subcutaneous tissue, and on the surface of organs, not penetrating into the parenchyma and not extending to the blood-vessels. It is to be added that they grow vigorously after death, penetrating into the substance of organs and into the vessels. In the mouse the bacilli penetrate more markedly during life into the tissues of blood-vessels, and the appearances approach to those of anthrax.

7. **Relapsing Fever.**—This disease is due to an active spiral microbe —the **Spirillum Obermeieri**—which is found abundantly in the blood of persons affected with relapsing fever. (See Fig. 54.) The spirilla are very thin with pointed extremities, and vary in length from two to six times the diameter of a red blood-corpuscle. They are present

only during the acute attacks, disappearing in the interval, to return when the relapse occurs. The spirillum is readily stained by ordinary watery solutions of the aniline dyes but not by Gram's method. It has not been cultivated artificially. The disease has been communicated to man and to apes by the inoculation of blood containing spirilla. The spirillum is found only in the blood, and Koch has observed it in the blood of the brain, liver, and kidneys of an ape which was killed during the attack. Metchnikoff has shown from experiments on animals that at the crisis the spirilla accumulate in the spleen, which in this disease is almost always enlarged. They are there in part disposed of by the leucocytes. If, as has been done by Soudakewitch, the spleen is excised and the disease then produced in the animal very large numbers of spirilla are found in the blood. The immunity conferred on man by one attack of this disease is very short-lived, and the same is known to be the case in the disease induced in monkeys. Lamb has shown that if the spleen of a monkey is excised, two or three weeks after it has passed through an attack of the disease, the animal may be proved to be immune. This he attributes to the bactericidal action of the serum, which he has demonstrated has the power of agglutinating and destroying the spirilla.

Malaria and **Dysentery** are dealt with elsewhere (see under Animal **Parasites** and Intestine).

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Western India, 1882; KOCH, Deutsch. med. Wochenschr., 1879; METCHNIKOFF, Virch. Arch. cix.; SOUDAKEWITCH, Ann. de l'Inst. Pasteur, v., 1891; LAMB in Scientific Memoirs of Medical Officers of the Army of India, Part xii., 1901.

III.—INFECTIVE TUMOURS. SPECIFIC NEW-FORMATIONS.

The affections in this group show in their structure and general relations considerable analogies to inflammation on the one hand and tumours proper on the other. Hence the conditions are variously called **Specific Inflammations, Specific New-formations** or **Infective Tumours**. As already indicated, the expression 'infective' means that the disease is 'spreading,' that it depends on some virus which propagates itself, and tends to reproduce the same kind of lesion outside its original seat. In most of the forms of disease included here, the exact nature of the virus has been made out, and in all of these except one it is found to be a microbe in the form of a short rod-shaped bacillus. It may perhaps be legitimately inferred that in the rest specific microbes are the infective agents. Several of these diseases are not only infective but infectious, communicable, that is to say, from person to person; some are capable of being inoculated into animals.

The virus has, to begin with, a local seat, where it acts in a concentrated form, inducing new-formation of tissue and inflammatory phenomena. The new-formation has many features in common with that of inflammation, but it has also certain distinctive or specific features. It consists chiefly of structures analogous to **granulation tissue**, not simply, as in inflammations, replacing a part of the normal tissue, but forming more or less independent masses which resemble tumours. Hence, the group of diseases included here is often designated **Granulation-tissue tumours** or **Granulomata**. Outside these more specific new-formations, there are usually the ordinary lesions of inflammation, the virus having acted in a less concentrated form.

But the tissue of the tumours presents certain differences from ordinary granulation tissue, chiefly in its tendencies. The granulation cells tend to undergo fatty degeneration and necrosis, and so the tissue may become caseous or break down. At the same time there is the more normal tendency to undergo development into connective tissue, and this may go on in an imperfect way alongside the other changes. Hence, the tumours frequently present great varieties in structure, and it is sometimes difficult fully to unravel their relations.

I.—SYPHILIS.

Causation.—This disease is obviously due to an infective agent. Lustgarten has described a bacillus whose connection with syphilis still stands in need of proof. He has found it in the secretions and in the tissues affected with syphilis. It is a rod-shaped organism somewhat resembling the tubercle bacillus, and is always found inside cells. It presents peculiar relations to staining agents, requiring treatment with gentian-violet, permanganate of potassium, and sulphurous acid. The position of this bacillus is doubtful, on the one hand because it is not found constantly in syphilitic lesions, and on the other because a similar bacillus—the smegma bacillus—has been found in the normal preputial and vulvar smegma. More recently Van Niessen has described and figured an organism which he classifies along with the higher bacteria, and Schüller has found in syphilitic lesions of all kinds bodies which he regards as animal parasites. The observations of both still stand in need of confirmation. Syphilis occurs only in the human subject, being transmitted from one person to another by contact.

Primary lesion.—The contagium is usually applied to some part of the external generative organs, but it may be applied elsewhere, as to the finger (in the case of a surgeon examining a part), to the lip, to the eyelid or other external part. After a period of incubation, usually extending to three weeks or more, it begins to show signs of local action. This is in the form of a papule or vesicle, which acquires a hard or indurated base, and so takes the characters of the **Indurated, Hard** or **Hunterian chancre.** This consists of a raised surface, whose base has a hard, almost cartilaginous feeling. Examined microscopically it is found that the true skin is entirely replaced by granulation tissue, which forms a bulky mass of round cells over which the epidermis may be continued or may be removed in some parts (see Fig. 55). This structure may be regarded as inflammatory, but it may also be regarded as a kind of tumour, and may be taken as the type of the syphilitic tumour.

In its less common seats it may very closely resemble another form of tumour. Thus a chancre of the lip may be mistaken for an epithelioma, and be excised under that impression.

The tissue, although like in structure to granulation tissue, does not readily form connective tissue, but remains long in the rudimentary condition, and when it disappears leaves comparatively little cicatrix. On the other hand, it sometimes becomes caseous, but this does not so readily occur in the primary lesion.

The virus is carried from the indurated chancre by the **lymphatics**, and lodges in the neighbouring **lymphatic glands**, where it again produces similar results, namely, a great production of ill-formed granulation tissue which has little tendency to develop into proper connective tissue, but readily undergoes an irregular caseous metamorphosis. The glands undergo a slow enlargement and become hard.

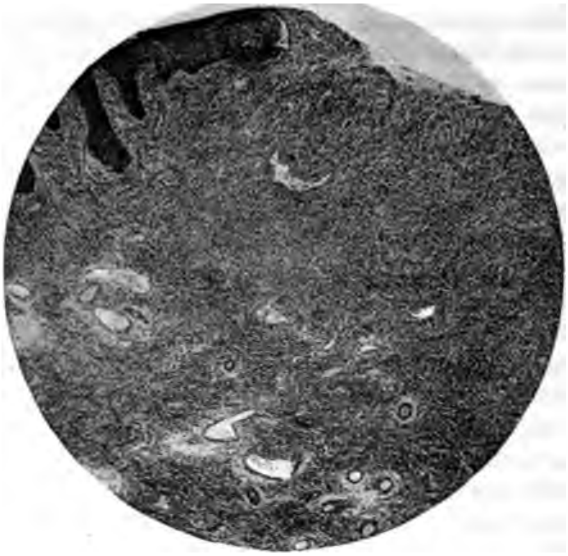

Fig. 55.—Hard chancre from prepuce. The margin of the ulcer is shown. ×40.

Secondary lesions. These are due to the fact that the virus passes from its local seat into the blood. This it eventually does, and after an interval of some weeks from the time of the primary lesion, the so-called secondary lesions develop.

The virus probably reaches the blood directly from the primary chancre, as well as by the lymphatics, but a certain period of time is necessary before it reaches the blood in sufficient quantity to produce any effect. Lang distinguishes in syphilis two periods of incubation, a **First incubation** extending from the time of infection to the appearance of the primary lesion, and a **Second incubation** between the primary and the secondary lesions. The first incubation has, according to the statements in recorded cases, a minimum duration of ten days, a maximum of forty-two days, and an average of twenty-four days. The second incubation is longer, having a minimum of eight to fourteen days, a maximum of one hundred and fifty-nine days, and an average of six to twelve weeks.

By some it is believed that the induration of the primary lesion is itself due to a constitutional infection, and they cite in proof of this the fact that auto-inoculation, from an indurated chancre, is rarely successful, that is to say, the person is already protected by the primary indurated chancre from the production of another chancre by inoculation. It is to be observed, however, that in all such cases the original chancre has the start of the inoculation, and before the period of incubation of the inoculation has elapsed there may be time for the blood to have been saturated with the virus. It is admitted that auto-inoculation is possible when done early enough. It seems scarcely possible to explain the second incubation except on the supposition that the primary lesion is, at least relatively, a local manifestation.

When an agent exists in the blood in a finely divided state it will be carried to all parts of the body, and if it produces lesions they will probably be symmetrical, as the corresponding parts in each lateral half of the body are for the most part in similar circumstances, and are similarly affected by any agent acting equally on them. The existence of symmetrical lesions is presumptive evidence that a disease is due to something in the blood. In the secondary stage of syphilis then we have the virus in the blood, and the result is symmetrical lesions of the skin, mucous membranes, bones, etc.

These secondary lesions are inflammatory in character, and have generally a resemblance to those of ordinary inflammations. They are most frequent in the skin, and so we have syphilitic Roseola, Eczema, etc., but other parts may be affected, and we have syphilitic Periostitis, Pharyngitis, etc. It is a question to what extent inflammations occur in internal organs in this stage; according to Hutchinson they are more frequent than is generally supposed, but are rarely seen because persons seldom die in the secondary stage.

The secondary stage has been aptly compared with the eruptive stage of specific fevers, it is like a fever long drawn out. There is in both cases a virus in the blood, and in syphilis there is frequently elevation of temperature. The analogy between the rash of secondary syphilis and that of measles, scarlet fever, small-pox, etc., is also suggestive, the skin affections in both classes of cases being inflammatory. During this stage, then, the virus is active in the blood, and the blood and secretions are contagious. The person is also in the position of transmitting the disease to the offspring, the virus passing into the germ and sperm cells. The virus dies out of the blood spontaneously, just as in the specific fevers, and the various secondary lesions disappear, generally in six to eighteen months.

In this secondary stage it is not common to meet with tumours like the indurated chancre. They are characteristic rather of the next stage, and when they do occur in this stage they are small and accompanied by more pronounced inflammatory manifestations.

A certain approach to the formation of granulation tissue, however, is often seen in the skin and mucous membranes during the secondary stage in the form of **mucous tubercles** or **flat condylomata.** These are flat superficial elevations of the that of the gumma, and with the same tendency to degeneration, so that the ulceration extends. As the tumour involves neighbouring structures which undergo necrosis along with the caseous process in the tumour, there may be great destruction of tissue brought about. In internal organs the caseous material may long lie apparently unaltered. The gumma may be virtually healed, its granulation tissue absorbed or converted into connective tissue, while the caseous matter remains, and is finally left in the midst of a cicatrix where it may become calcified.

We have still to inquire what may be the relation of these tertiary lesions to the virus. The virus no longer exists in the blood, and in accordance with this the lesions are characteristically unsymmetrical. The most probable supposition is that, after the close of the secondary stage, some of the virus has remained lying in a particular part. Perhaps a small gumma has formed, and the virus has lain in it quiescent but still surviving. It may be waked up by some accidental circumstance in the life of the patient, at any period afterwards, perhaps as long as twenty years. The virus propagates itself, but its effects are local. It may produce a tumour of large size, but it does not pass into the blood, and therefore does not produce the lesions of the secondary stage. It has been a matter of dispute whether a tertiary gumma is an infectious lesion, and the fact that the blood of the patient himself does not become infected might seem to answer the question in the negative. It is to be remembered, however, that the affected person already possesses an immunity by having passed through the secondary stage. The gumma is probably capable of producing syphilis when its juices are brought into contact with the tissues of a susceptible person.

While the conditions described as characteristic of the tertiary stage usually succeed those of the secondary period, it should be understood that there are great variations both in degree and order of occurrence. The secondary manifestations may be greatly prolonged, and the tertiary may develop to some extent coincidently. The seat of the tertiary lesions varies very greatly.

The tertiary stage of syphilis is often in its later period associated with **Waxy** or **Amyloid disease**. This may be due in some cases to chronic suppurations induced by the specific lesions, but the observations of Fagge show that it is not always so. Of 76 cases of amyloid disease associated with syphilis there was evidence of former or present bone disease only in 34. In the total autopsies in cases of syphilis over a period of years, amounting to 177 cases, amyloid disease was present in 76 cases or 43½ per cent.

The **absorption of a gumma** may be promoted by the administration of remedies.

The exact process by which this is brought about is hardly known, but there seems to be a simple fatty degeneration with absorption, in a way indicated in the section on fatty degeneration.

Syphilis is often associated with a **condition of the arteries** which will come up for discussion further on. Wherever there is, as so frequently happens, a considerable formation of granulation tissue passing into connective tissue, the arteries take part in the inflammation, and we have, especially, thickening of the internal coat sometimes going on to complete obliteration of the calibre of the vessel. (See Figs. 58 and 59.) This is sometimes very strikingly seen in the neighbourhood of gummata (see Fig. 57), and by diminishing the blood-supply, it may contribute to the degeneration of the gumma. It may also lead to degenerations in parts around, as where softening of the brain occurs in connection with gummata.

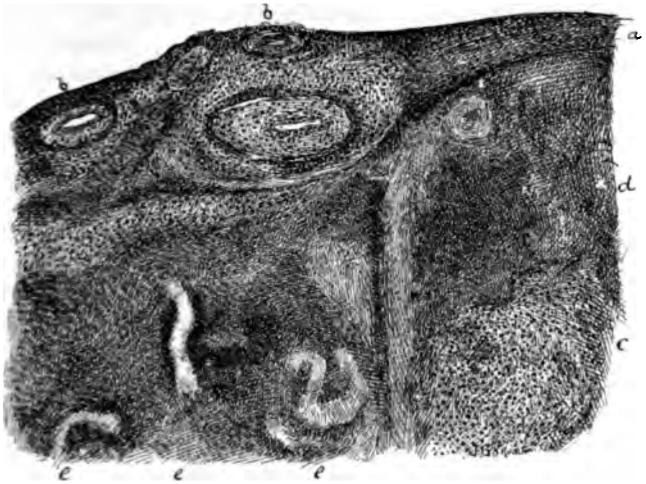

Fig. 58.—Syphilitic affection of meninges and brain. *b*, *b*, Arteries showing thickening of internal coats.

Hereditary syphilis.—We have already seen that syphilis, in the secondary stage at least, may be transmitted to the offspring. In the acute period death often occurs *in utero*, or the child sickens soon after birth and dies within a few weeks. But it often happens that the children do not show any evidence of syphilis for months or years. In this way we may distinguish cases of **congenital** syphilis from cases of simple **hereditary** syphilis, the former being born with syphilitic lesions, the latter developing them afterwards.

In **Congenital syphilis** the most constant and unequivocal lesion is the affection of the bones, which will be considered afterwards. In this condition there is an error in the process of ossification, with inflammatory conditions. Not infrequently the **Liver** is the seat of changes, chiefly in the form of diffuse cellular infiltrations going on to the formation of fibrous tissue. (See under Liver.) The new-formed fibrous tissue insinuates itself between the hepatic cells, separating them from each other in small groups as shown in Fig. 60. The **Lung** also may be similarly affected. There is a marked increase, over a larger or smaller area, of the interalveolar connective tissue, with consequent consolidation. Proliferation and desquamation of the alveolar epithelium is common (see Fig. 61). The term **White Pneumonia** is sometimes applied to the condition, the lung being firm, heavy, and of a whitish-grey colour.

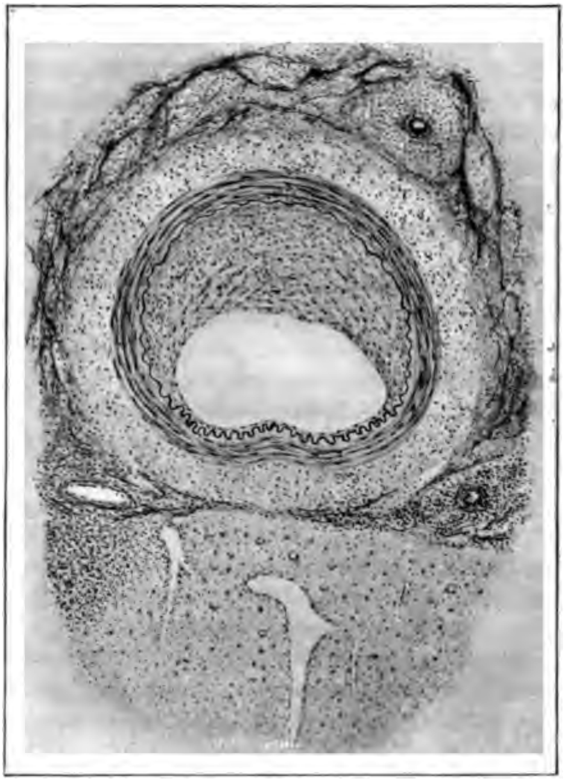

Fig. 59. Syphilitic endarteritis. The thickening of the interna and the extension of the brain substance are clearly shown. ×50.

In **Hereditary syphilis** the lesions are, like those of the secondary stage, mainly inflammatory. There are inflammations of the skin, mucous membranes, cornea, etc. The characteristic malformation of the teeth which Hutchinson has pointed out seems related to inflammation of the mucous membrane of the gums during the development of the teeth.

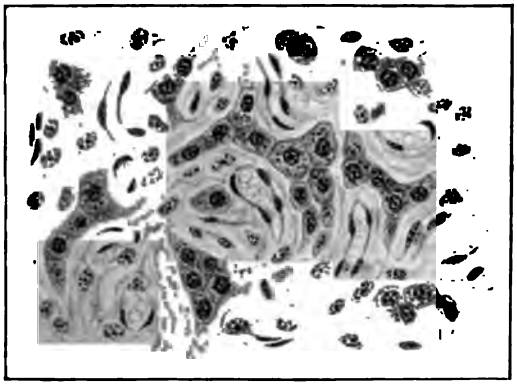

Fig. 60.—Congenital syphilitic cirrhosis of liver. ×400.

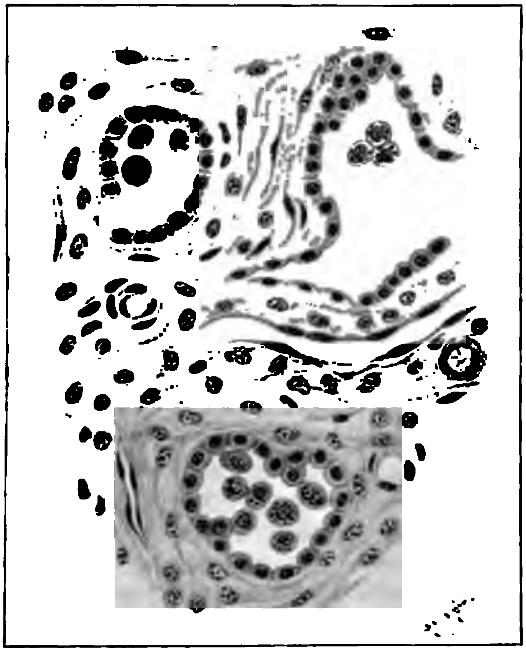

Fig. 61.—Congenital syphilitic interstitial pneumonia. ×300.

Literature.—The author, in describing the general pathology of syphilis, has followed chiefly Hutchinson and Virchow. HUTCHINSON, On Syphilis, 1887, and Debate on Syphilis, Path. trans., vol. xxvii., 1876; see also other speakers in this debate; VIRCHOW, Krankhafte Geschwülste, ii., p. 393; LANG, Path. und Therap. der Syphilis, 1896, also articles with literature in Twentieth Cent. Pract. of Med., 1899, and Lubarsch und Ostertag's Ergebnisse, 1900; RICORD, Traité prat. des malad. vén., 1838; LANCEREAUX, Traité hist. et pratique de la syphilis, 1866; HILTON FAGGE, Medicine, vol. i., p. 109, and Path. trans., vol. xxvii.; KASSOWITZ, Die Vererbung der Syphilis in Stricker's Med. Jahrb., 1875, p. 359; FOURNIER, Leçons sur la syphilis, 1881; VAN HARLINGEN, International Encycl. of Surgery, vol. ii., 1882. *Bacillus of Syphilis*—LUSTGARTEN, Med. Jahrb. d. Wien. Gesellsch. der Aerzte, 1885; BITTER, Virchow's Arch., cvi., 1886; VAN NIESSEN, Centralb. f. Bact., xxiii., 49, 1898; SCHÜLLER, ibid., xxxii., 1902.

Frambœsia or **Yaws** is a disease which has many analogies with syphilis. It will be considered under Diseases of the skin.

II.—TUBERCULOSIS.

Tuberculosis is an infective disease in which the tissue-changes are due to the action of a specific virus or infective agent. As in the case of syphilis there is always a local or primary lesion, but the infective agent does not usually extend to the blood and infect distant parts of the body. On the other hand, the local lesion is, for the most part, a constantly extending one, infecting neighbouring parts till the death of the person, which is usually brought about, directly or indirectly, by the tubercular process.

Causation.—While tuberculosis is due to a specific virus—the tubercle bacillus—there are undoubtedly conditions of the body which predispose certain persons to its action. Considering that this virus is very largely present in nearly all inhabited places, it must be apparent that most people are exposed to its action, and yet only a limited number of persons become affected. The predisposition is frequently the result of inheritance. It has been abundantly proved to be so in the case of the commonest form of tuberculosis, namely, that of the lungs, but not so obviously in other forms. Inheritance determines a local predisposition usually in one organ or system (*vide ante*), but when a tuberculosis is once established in the body it is not uncommon to find it extend by one path or other to other organs, even without there being evidence of a general extension by the blood.

The bacillus is present in somewhat varying degrees of abundance in different tubercular lesions, but it has been met with in all forms of tuberculosis. The connection of the bacillus with tuberculosis and the essential identity of the various forms of the disease have been proved by the cultivation of the microbe outside the body, and by the results obtained by inoculating the cultivated products.

Bacillus tuberculosis.—The great frequency of tuberculosis both in man and animals renders the discovery of the bacillus by Koch one of the most important results of science in this century. The merit of this discovery is the greater as the tubercle bacillus is peculiarly difficult both to observe in its usual seats and to cultivate. Hence special methods of staining and special culture media are employed.

The bacillus is a thin, rod-shaped cell, rather shorter than the diameter of a red corpuscle. It is often slightly curved. (See Fig. 62.) The bacilli are mostly single, but occasionally in pairs attached so as to form an angle, more rarely in longer threads. They do not possess power of movement. They usually present a beaded appearance, and the beads have sometimes been regarded as spores. The remarkable persistence of the tubercle bacillus, and the manner in which it retains its infective powers when dried or when kept in putrid fluids, indicate that it is capable of offering considerable resistance to external influences, though whether this be in the form of spores or not is not definitely known. While these are the more common morphological characters of the bacillus occasionally deviations in form are observed. Large filaments with clubbed extremities, branched filaments, and forms resembling those of the actinomyces are found under certain circumstances. These are probably not to be interpreted as degeneration—or involution—forms, but rather to be taken as evidence that the bacillus belongs to the class of higher bacteria, and is closely allied to the streptothriceæ.

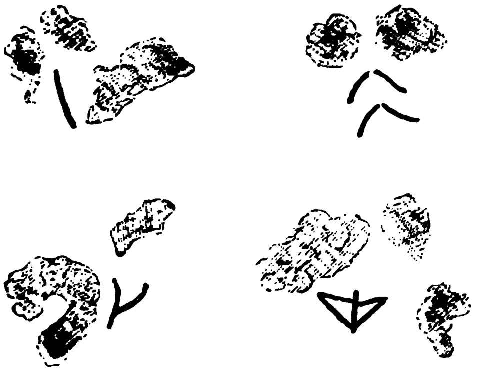

Fig. 62.—Tubercle bacillus from sputum in phthisis pulmonalis. × 1500.

In artificial cultures the bacillus is very slow of growth and difficult of cultivation. Recently it has been proved that these difficulties may be overcome if the microbe is previously cultivated in some modified medium or grown in the bodies of certain amphibia. The best medium is solidified blood serum, but agar may be made available for the culture by the addition of 6 to 8 per cent. of glycerin (Nocard and Roux). The bacilli require for their growth a temperature above 30° and under 42° C., and the best is near the temperature of the body, namely, 37·5° C. In about ten to fourteen days after implantation the growth first appears as dry whitish scales, which are entirely superficial. Under the microscope the scales are seen to be composed of colonies of bacilli, which from their arrangement, form curved lines, some of them like the letter S (see Fig. 63). The growth goes on for three or four weeks, and remains superficial all the time. The culture may be propagated through many generations, the bacilli retaining their morphological and pathogenic characters. Sunlight is very inimical to the bacilli. Direct sunlight kills cultures in a few minutes, and even diffused daylight destroys them in a few days.

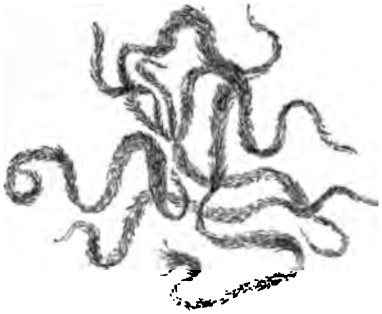

Fig. 63.—Tubercle bacilli, forming typical growths. × 700.

The tubercle-bacillus, as we have seen, grows slowly and only at a temperature approaching to that of the living body. We may therefore infer that it does not to any appreciable extent multiply except in the body, as the conditions will seldom be favourable, as regards soil and temperature, unless these are carefully arranged for experimental purposes. On the other hand, the bacilli are very resistant to external influences, so that they retain their vitality under adverse circumstances, and are ready to begin growth when they obtain a suitable nidus. The bacilli and spores survive even when dried, and they may be suspended in the air and carried as dust, ready to deposit on surfaces or to be inhaled during respiration. Tuberculosis is [illegible] commonly produced by direct communication by contact between person and person, in this respect contrasting with syphilis.

In man the bacilli are introduced accidentally by inhalation, by food, or by inoculation. When they attack the skin they pro[illegible] lupus or scrofuloderma, and when they affect the lungs, ph[illegible] pulmonalis; when introduced with the food they rarely affect [illegible] intestinal canal, but are usually carried to the lymphatic [illegible] where they produce tuberculosis. According to Cornet the [illegible] bacillus is not commonly present in the dust of dwellings, but is present when the expectoration of consumptives is allowed to dry and become pulverized on the floor or in handkerchiefs.

Tuberculosis is producible in animals by administering either the products of disease (such as dry sputum or portions of caseous matter) or cultures. It has been induced by inoculation under the skin or into the anterior chamber of the eye, by injection into the serous cavities or into the veins, by inhalation and by ingestion with the food. Except when directly introduced into the blood, there is first a local tuberculosis, which may be followed by a generalization of the disease. It has been shown that the injection of even dead bacilli in sufficient numbers will induce tubercle-like nodules in the tissues, slight caseation of the lesions, and by general weakness and emaciation lead to death, the dead bodies of the bacilli containing evidently within them a poison similar to that which they elaborate during life.

The bacilli produce their results mainly by means of irritant products which they evolve. These products are present in cultures of the bacillus, and are separable from the microbe itself. The so-called **tuberculin**, which Koch first introduced for the treatment of tuberculosis, is a glycerin extract of such cultures. It is an exceedingly active agent, an extraordinarily minute dose introduced hypodermically inducing serious general symptoms.

The minimum dose of Koch's fluid is one gramme of a fluid which has been thrice diluted to the extent of 10 times. The gramme thus contains $\frac{1}{1000}$ of a gramme of the original fluid, or about $\frac{1}{60}$ of a minim. Koch calculates that the original fluid contains about 1 per cent. of the essential principle, and the minimum dose will therefore contain $\frac{1}{100000}$ of essential principle or $\frac{1}{6000}$ of a grain. Such a small quantity as this, in a person who is already tuberculous, often sends the temperature up rapidly and produces marked local disturbance.

These products, evolved by the bacilli in the living body, have somewhat varying effects. The resulting lesions are in part specific new-formations, which are called tubercles, and in part the more usual results of ordinary inflammation. These two, the more specific and the more ordinary lesions, are generally both present, but the one or the other may exist alone.

The infective nature of tuberculosis does not rest alone on the facts connected with the bacillus; it was inferred long before the discovery of this micro-organism. The most direct proof consisted in the production of tuberculosis by the inoculation of tubercular material in animals. This was first demonstrated by Villemin in 1865, and was repeatedly confirmed by many observers, among whom may be mentioned Lebert, Waldenburg, Klebs, Cohnheim, Tappeiner, Bollinger, before the discovery of the bacillus in 1882. Tuberculosis may be readily produced in animals, and the material used may be tubercular products obtained from post-mortem examinations or otherwise, the sputum of patients suffering from phthisis pulmonalis, or artificial cultures of the bacillus. The disease has been induced by inoculation (Cohnheim, Koch, Baumgarten), by inhalation (Tappeiner), and by feeding (Wesener, Bollinger).

As an example of the mode of inoculation and its results we quote the following from Koch's work on the Etiology of Tuberculosis (Sydenham Society's translation 1886). It recounts the effects of inoculating fragments of tissue from variou organs in cases of human tuberculosis, such as from the lungs in phthisis, from strumous joints, scrofulous glands, lupus, and from tuberculosis in variou animals.

"The inoculation was effected by making a small incision in the abdominal wal of a guinea-pig with the scissors, inserting the point of the scissors to form a pocket-like subcutaneous wound, about half a centimetre deep. Into this littl pocket a fragment of the inoculation substance about the size of a millet o mustard-seed was pushed as deeply as possible. On the following day the inoculation wound was always united, glued together, and showed no reaction. Generally it was not till after a couple of weeks that a visible swelling of the lymphatic glands next the seat of inoculation occurred, usually the inguinal glands on one side, and at the same time induration and the development of a nodule took place in the inoculation wound, which up till then had remained perfectly healed. After this the lymphatic glands enlarged rapidly, frequently to the size of a hazel-nut. The nodule at the seat of inoculation then generally broke and became covered with a dry crust, beneath which was a flat ulcer with a cheesy floor discharging very slightly. The animals began to lose flesh about this time, their coat became bristly, dyspnœa set in, and they died generally between the fourth and eighth weeks, or they were killed within the same space of time."

Tuberculosis has been induced or observed in **nearly all the commoner warm-blooded animals**, and according to Koch no bird or mammal is capable o permanently resisting infection. Animals show, however, very different degrees of susceptibility, and in similar degrees they are variously liable to spontaneous tuberculosis. Rabbits, guinea-pigs, cattle, and apes are peculiarly susceptible. Carnivorous animals are much less so, but, according to M'Fadyean, spontaneous tuberculosis is more common in dogs than is commonly supposed. In any given class of animals the individuals show varying susceptibility just as in the case of man.

The infective character of tuberculosis is also to be inferred from the spreading character of the lesion, to be now described.

Contagiousness of tuberculosis.—As the tubercle-bacillus from its mode of growth is propagated only in the animal body, except as a laboratory experiment, the disease must be contracted more or less directly by contagion. According to Cornet, as we have seen, the great source of contagion is the dust formed when tuberculous products, and especially the sputum of phthisical persons, is allowed to become dry and is pulverized. This author asserts that even strong persons are susceptible when exposed to such dust. It is thus by an intermediate process that infection usually occurs. Direct infection is rare. One of the most obvious cases of the latter is afforded by the chronic thickenings or warts to which pathologists are liable from infection at post-mortem examinations.

It is apparent that if the bacillus could be entirely got rid of in the community the disease would necessarily cease. This can only be effected by a system of isolation along with disinfection of discharges. The facts that about one-seventh of the deaths in the community are due to tuberculosis, and that probably not less than one-half of the persons born are fated to acquire the disease in some form, ought surely to justify such precautions. In this connection it is of importance to note that leprosy, under a system of rigid isolation, almost disappeared from Europe, and this surely affords a presumption in favour of similar precautions in the case of tuberculosis, which however can be carried out without any such cruel seclusion as in the case of lepers.

Inheritance of tuberculosis.—While inheritance plays a very important part in the predisposition to tuberculosis, it has not yet been proved that, in man, tuberculosis is ever communicated from parent to offspring, although there are a few cases recorded in infants which may have been congenital. This is consistent with the fact that the bacilli do not readily pass through membranes. Johne has recorded a case of congenital tuberculosis in a calf whose mother was affected with severe tuberculosis of the lungs. In the calf the tuberculosis was situated in the liver, portal glands, and bronchial glands, the infection having been by the umbilical veins in the placenta. (Referred to by Birch-Hirschfeld.)

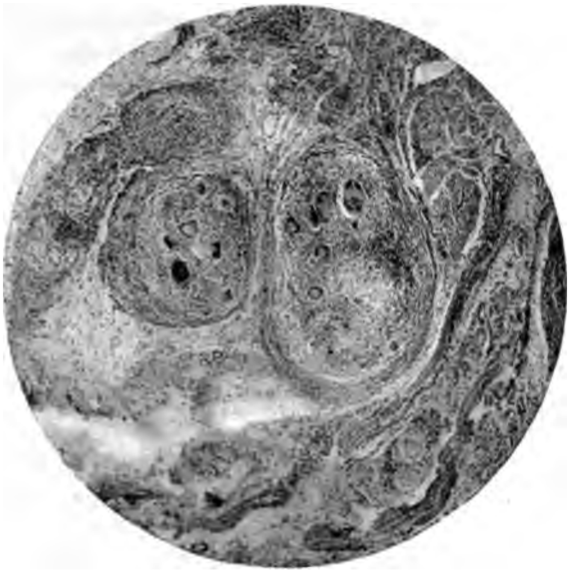

FIG. 64.—Tubercles from a case of tuberculosis of the tongue in a child. ×45.

Character of the lesion.—The typical lesion in tuberculosis is the so-called miliary tubercle, and it is this which was referred to above as being the specific product of the action of the virus.

The miliary tubercle is a minute rounded body (Figs. 64 and 65) composed of cells and devoid of blood-vessels. A single tubercle is scarcely visible to the naked eye, but, by the confluence of several, there may be larger nodules formed, and even, by the concurrence of vast numbers in successive generations, large masses. At first sight the tubercle seems composed simply of round cells, but closer inspection shows usually three forms of cells to be present. The most peculiar and typical is the **Giant-cell**, which in the early stages is nearly a constant constituent. It is a large body (seen in the middle in Fig. 65) presenting at its margin radiating processes, especially at its poles, and containing numerous oval nuclei, usually arranged in a row near the periphery of the cell. The giant-cell is generally near the centre of the tubercle, but may be considerably removed from this position. There are frequently several in one tubercle (see Figs. 64, 65, and 66). The second constituents, the so-called **Epithelioid cells**, are smaller than the giant-cells and possess one nucleus, but are still of considerable size. They are similar in form and origin to the formative cells in the inflammatory new-formation. They surround the giant-cell, and in their general appearance somewhat resemble it. **Ordinary round cells** form the third constituents, and they are variously abundant according to circumstances. They are chiefly lymphocytes with nuclei which stain deeply; among them polymorphonuclear leucocytes are visible.

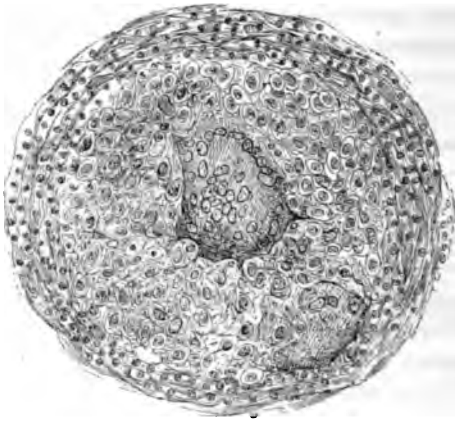

Fig. 65.—Tubercle more highly magnified showing constituents. A giant-cell is in the middle, and a smaller one lower down. Epithelioid cells form the rest of the tubercle except at the margins, where round cells are present.

The round cells are present at first at the periphery, and may be regarded as representing the ordinary inflammatory products, which are commonly seen in the tissue around. The giant-cells and epithelioid cells seem to be the essential constituents of tubercles, and in perfectly recent examples they may be almost the only ones. They are, according to Baumgarten, the immediate products of the action of the tubercle bacilli, the round cells being the ordinary result of inflammation.

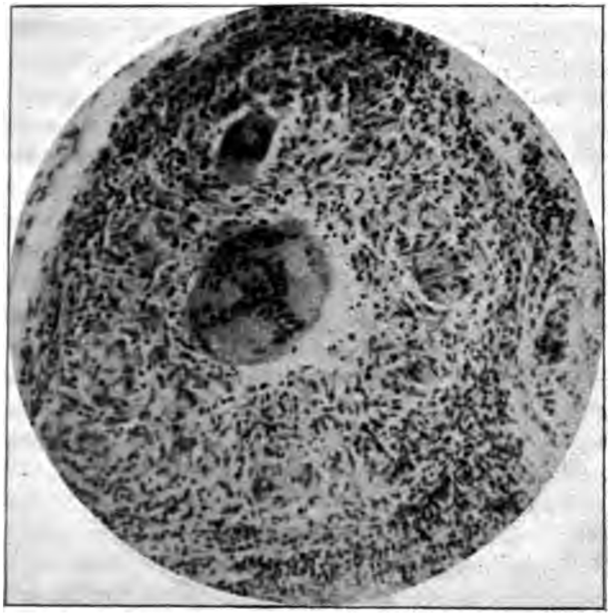

Fig. 66.—A tubercle from the synovial membrane with two giant-cells. × 120.

Baumgarten, from a very elaborate series of experimental studies, has described **the Origin of the various constituents of the tubercle**, and their relation to the bacilli. When bacilli invade a tissue the fixed cells of the tissue, those of epithelium as well as the connective tissue, first show evidences of change. They are induced to proliferate by the bacilli which may be in their substance or in the neighbourhood. The nuclei of these cells show karyokinetic figures, and both giant-cells and epithelioid cells result from the changes in the fixed cells of the tissues. In the case of the giant-cell the nuclear division goes on, but the cell division does not ensue, there being thus a kind of arrest of development. By this process a rounded tubercle arises which is composed entirely of giant-cells and epithelioid cells. But the neighbouring blood-vessels are affected by the virus, and from them an emigration of leucocytes occurs. The leucocytes are at first outside the large-celled tubercle, but penetrate into it, and may convert it into a small-celled or lymphoid tubercle. This transformation may be rapid or slow, its course depending on the number and energy of the bacilli. If the latter are abundant and vigorously propagating, or if they are accompanied by other foreign microbes, then the production of leucocytes may be very great, and the tubercles rapidly pass into the small-celled condition. This may occur so rapidly that the large-celled condition may be almost omitted. Hence it is where the bacilli are comparatively few and the cultivation pure that the large-celled non-inflammatory tubercle is most typically seen.

Bodies having a structure similar to that of tubercles may be produced by the presence of small foreign bodies (rabbit hairs, Baumgarten; particles of stone, Hamilton), but in all such cases the lesions have not an infective character. A more near approach to the true tubercle is met with in Actinomycosis, where the presence of a microbe has the effect of producing results not unlike those of tuberculosis (see Actinomycosis).

The typical tubercle, as here described, is not infrequently difficult of recognition in actual cases. Inflammatory processes occurring around and invading it, obscure its structure, and the tubercle itself is prone to degenerative changes.

Caseous necrosis or **Caseation** is the most characteristic change in tuberculosis. This change consists in necrosis with fatty degeneration

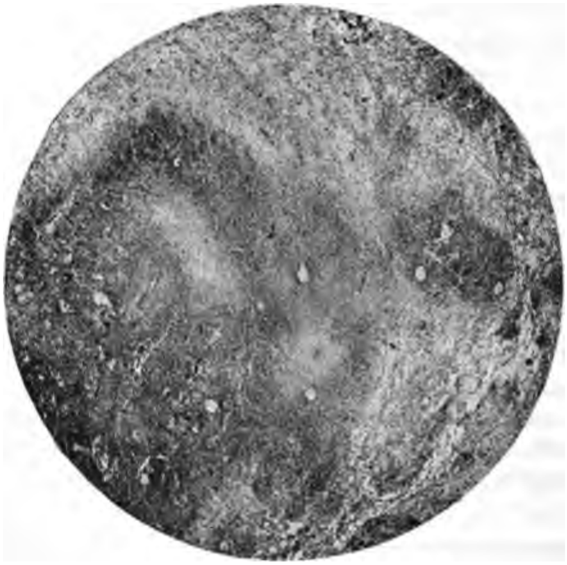

Fig. 67.—Caseous tubercle in spleen. The opaque structureless material is seen in the centre of the figure. × 35.

of the structures (see Retrograde changes). It manifests itself in a granular condition of the cells, whose nuclei disappear. The result is an obscuration of the structure, and the replacement of it by a homogeneous structureless and somewhat opaque material. This change usually begins in the central parts of the tubercles, it may be in the giant cell, and produces an opacity there, but it is liable to overtake the whole structure (see Fig. 67). Indeed, it extends to the parts around, so that the tissue which is merely infiltrated with inflammatory products is frequently involved in the caseation. Hence, when the process has overtaken a considerable portion of tissue, the structure may be much obscured. This process in the rapidity and completeness of its occurrence depends on the abundance and vigour of the bacilli. Where they are numerous, and where consequently there is much infiltration with leucocytes, caseation is rapid (Baumgarten). The caseous material so produced is a yellow, brittle substance, which resembles cheese in its appearance. So characteristic is this result of tuberculosis that caseation is almost equivalent to the older term **Tuberculization**, and caseous matter to **Crude** or **Yellow tubercle**.

In very acute cases we may have an approach to ordinary necrosis or sloughing, or at least an acute softening.

The process of caseation is to be related to the action of the virus. It is a necrosis due to the toxic action. Some have endeavoured to account for the caseation by the absence of vessels in the tubercles. But much larger pieces of matter may be kept alive in the body without the intervention of vessels, such as free bodies in the joints or abdomen. Besides, the caseation extends beyond the tubercles to the tissue around, which is vascular.

Fibrous transformation is a much more unusual change in tubercles, and occurs only where the process is very chronic and the bacilli very few. While some tubercles undergo caseation, others, and along with them the surrounding tissue, develop fibrous tissue, like that in chronic inflammation.

Softening is the usual result of caseation. The caseous matter, although it may remain for a time unaltered, in most cases ultimately liquefies or breaks down. The result is the formation of a **Cavity** or **Ulcer** (see Tubercular Ulceration of Intestine). It is to be remembered that, as the caseation involves not only the tubercles but the surrounding tissue, the cavity or ulcer is associated with an absolute loss of tissue. The walls of the ulcer are tubercular, and the disease usually continues advancing, so that the ulcer or cavity enlarges.

On the other hand, **the caseous matter may accumulate** without softening, and we may have considerable masses of it, such as we find in the brain in the form of the tubercular tumour or scrofulous tubercle and in the lymphatic glands. In course of time the caseous matter may be partly absorbed, or may undergo **Calcareous infiltration** (see Fig. 68).

Scrofula and Struma.—These terms are used to designate conditions of the lymphatic glands, which are now generally recognized as tubercular. They will be described in their proper places. The terms have been somewhat indefinitely extended so as to include affections of joints, bone, skin, and other structures, but such affections are nearly all really tubercular.

Local Tuberculosis.—We have already seen that tuberculosis is always, to begin with, a local affection, due to the implantation of bacilli in the living tissue, and it may be added that, even when it becomes generalized, the secondary lesions are due to the multiplication of bacilli transplanted from the primary seat, the growth of the microbe occurring not in the blood but in the local seat. Hence the description already given applies to the local process however originating.

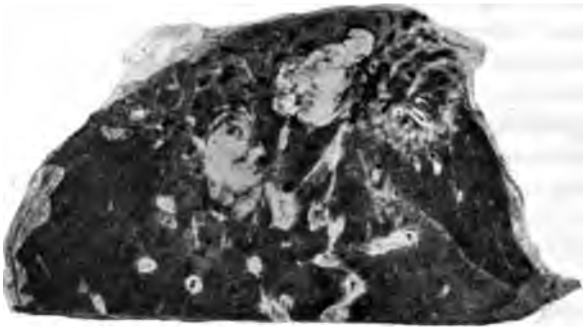

Fig. 68.—Caseous and cretaceous masses in apex of lung.

The bacillus finds access to the body by various channels. The most common seats of tuberculosis are in direct communication with the surfaces of the body. The commonest seat of all is the **Lungs**, and entrance is here obtained with the inspired air (see Fig 69). Next to the lungs the **Lymphatic glands** are most frequently affected, and in the case of children they are perhaps more frequently the seat of tuberculosis than the lungs. The lymphatic glands which are attacked are in communication either with the skin or a mucous membrane, and there are frequently catarrhs or other forms of inflammation in the tissue with which the affected glands are related. The bacilli may, however, find their way from surfaces which are unaltered. The glands most frequently affected are those of the neck, communicating with the mouth; of the bronchi, communicating with the lungs; and of the mesentery, communicating with the intestines. **The skin** may be directly attacked by tuberculosis, the resulting conditions being described as Lupus, Scrofuloderma, Post-mortem wart, etc.

While these more direct modes of entrance obtain in the majority of cases, there remain a large number in which the access is more circuitous. In some of these the tuberculosis is due to a secondary extension from a tubercular lymphatic gland. It is thus that many cases of tuberculosis of **Serous membranes** arise. But in a considerable number of cases, the bacilli can only have found access by the blood. The blood is not infrequently the vehicle by which small solid particles are conveyed, and we may suppose that a few bacilli accidentally present may be deposited in the tissues, and, in the case of a susceptible organ, may multiply and produce a tuberculosis. This applies to tuberculosis of the **Bones**, which is very frequent in children, and which often begins in the vertebræ, or in the cancellous tissue at the extremities of the long bones. **The Brain** is also liable to primary tuberculosis, especially in children. Tuberculosis of the **Urino-genital** system begins very frequently in the testicle, and the bacilli are carried thither by the blood.

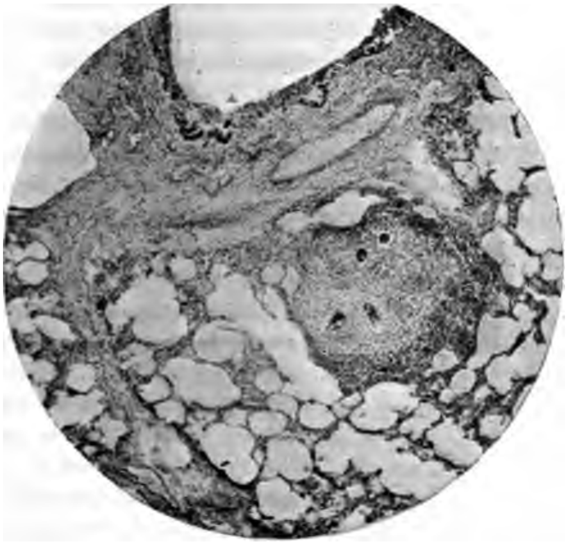

Fig. 69.—Tubercle with giant-cells in the peribronchial connective tissue from a case of chronic tuberculosis of the lung. × 35.

Extension of local tuberculosis.—A tuberculosis once established in a locality presents usually a tendency to indefinite extension. Tuberculosis is generally a slow process, and the extension is also chronic. The extension is to the immediately neighbouring parts, by direct infiltration, or, more commonly, by the *lymphatics* or along surfaces and canals. The process of extension is usually stopped by the intervention of a membrane, as the bacilli seem not to be possessed of the power of penetrating membranes unless there is first a necrosis of them. Thus, tuberculosis of lymphatic glands does not pass through the capsule unless the latter have been perforated by necrosis; and tuberculosis of the lungs rarely extends to the pleura unless there be actual perforation of that membrane.

Extension by the lymphatics is very frequent and characteristic. Tubercles often form in the course of the lymphatic vessels connected with tubercular organs, as well as in the lymphatic glands. In phthisis pulmonalis, for example, there are tubercles in the substance of the lung seated in the lymphatic vessels, while the bronchial glands are also the seat of tuberculosis.

The extension along surfaces and canals is exemplified chiefly in serous and mucous membranes. A tuberculosis occurring in the pleura, pericardium, or peritoneum extends over the entire surface of these membranes. Tuberculosis, in communication with mucous canals, frequently travels considerable distances, involving the surface more or less continuously, but penetrating deeply to a very slight extent. Thus, tuberculosis of the lungs is frequently associated with tuberculosis of the bronchial mucous membrane, of the mucous membrane of the trachea and larynx, and of the intestine (from swallowing the expectoration). Again, tuberculosis of the genito-urinary organs frequently begins in the testicle. From this it may extend the whole length of the vas deferens to the vesiculæ seminales and urinary bladder, and sometimes up the ureter to the kidney.

One may here recall the facts that in artificial cultures, the tubercle-bacillus grows on the surface of the medium, and does not penetrate into its substance.

While tuberculosis does not readily penetrate deeply, still in vascular organs a few bacilli will occasionally reach the blood, passing either directly into the vessels of the part, or indirectly by the lymphatics. These may settle in predisposed situations, and give rise to **secondary tubercular lesions in several different centres.** This condition has been called by Weigert "chronic general tuberculosis." When a few bacilli, thus at intervals, find entrance to the blood, the lesions will usually be comparatively few. These secondary lesions run a chronic course, and may sometimes rival the primary tuberculosis in size and effect on the body. There may thus be a number of considerable tubercular lesions in different organs, and the case frequently *looks like* one in which several local tuberculoses are simultaneously present. This form of disease is most frequently seen in children, whose tissues seem more susceptible to the tubercle bacilli in smaller numbers than those of adults. In them we may find tubercular masses simultaneously in lungs, kidneys, brain, etc.

Effects of local tuberculosis.—The process of tuberculosis, as already described, involves destruction of tissue, and in many cases ulcers and cavities are the result. The destruction of tissue may itself involve serious consequences, as in the case of the bones and of the brain, in which latter position the tubercular mass also acts as a tumour, pressing on the brain substance around. Most of the evil consequences, however, arise in connection with ulceration and formation of cavities. The surfaces thus produced discharge and use up the available nutritious material of the body. Such processes are, therefore, accompanied by **Emaciation.** Even more potent in the production of general emaciation is **Fever**, which commonly accompanies tuberculosis. Fever in general is produced by the presence of foreign matter in the blood (see further on). In tuberculosis the bacilli do not produce fever directly, as they are not present in the blood, but their products are, in a dilute form. In the case of discharging surfaces, again, there will commonly be putrid and other forms of decomposition in the matter discharged, and the absorption of the products will still further conduce to fever.

General Tuberculosis.—This term is used in contradistinction to local tuberculosis, to designate a condition in which the tuberculosis has not one but many centres to which the virus has been carried by the blood. It has been pointed out above that tuberculosis has little tendency to penetrate deeply, preferring to extend along open channels or surfaces. Hence, the disease, for the most part, remains local. When conveyed into the blood, the bacilli may or may not settle down and multiply. This will depend on the number and vigour of the bacilli, and the resisting power of the tissues. If they are present in large numbers, as where a local lesion bursts into a blood-vessel, then they are planted in many organs, and

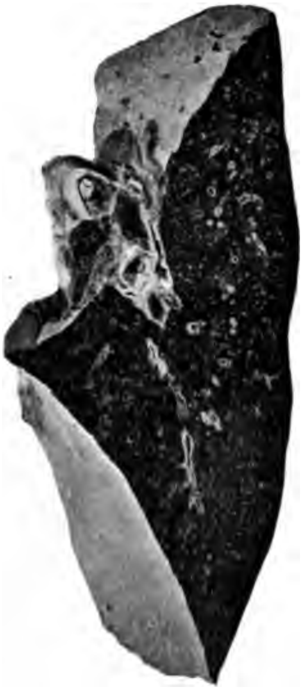
Fig. 70.—Portion of lung of child in acute miliary tuberculosis.

produce their usual effects, namely, the formation of tubercles inflammation. Hence, in general tuberculosis we have what is e valent to a multitude of local tuberculoses.

For the most part the disease is a very acute one, hence the na **Acute general tuberculosis** and **Acute miliary tuberculosis.** The a simultaneous and wide-spread eruption of tubercles in several org The tubercles have the usual structure, but they are present in numbers in the lungs (see Fig. 70), liver, spleen, kidneys, sometime the meninges, lymphatic glands, supra-renal capsules, etc. They

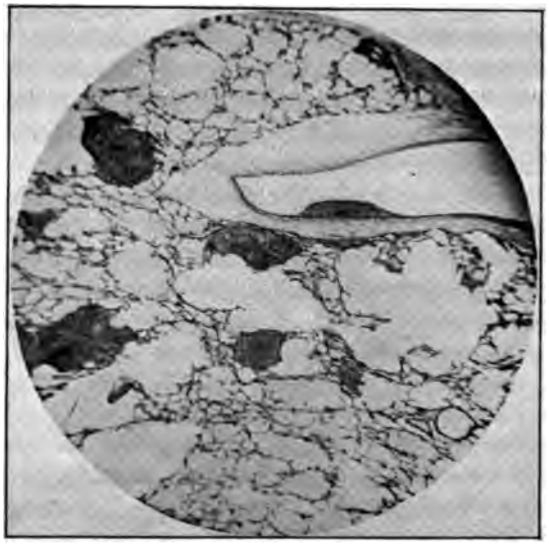

Fig. 71.—Photograph of a section of lung in a case of acute general tuberculosis. A tubercle has formed inside an artery.

sometimes be seen in the heart-wall and endocardium. Accordin Tripier the bacilli may settle on the valves and produce an acute tu cular endocarditis, in his case of the mitral valve. The tubercles o show their relation to the circulation by their connection with blood-vessels. In the lungs they are very frequently grouped aro the smaller arteries, and may even form in the internal wall of artery, projecting into its calibre. This is shown in Fig. 71, and an appearance is not uncommon. The disease is an acute febrile fatal in a few weeks, and the individual tubercles are small in size, local formation being little more than a single miliary tubercle. T are often so small as to be only detectable by the aid of the microsc especially in the liver, where they are present in almost incred numbers.

The simultaneous outbreak of numerous tubercular lesions implies that in a short interval the blood has received large numbers of bacilli. In some cases the bacilli have been detected in the blood during life (Weichselbaum), and not infrequently after death.

This overloading of the blood with bacilli can only occur when tuberculosis has extended so as to involve the wall of a still pervious vessel of some size, so that the bacilli may find free access to the blood. Acute general tuberculosis has been found associated with tuberculosis of the thoracic duct, of the pulmonary, splenic, portal, hepatic, and other veins. The extension may also occur from lymphatic glands directly into the blood-vessels of these glands (Koch).

This solution of the problem of acute general tuberculosis was first suggested by Ponfick, who observed tuberculosis of the thoracic duct in a case of this disease. Weigert has, in a large proportion of cases, found the source of the general infection in the extension to pervious veins, and he asserts that in most cases such a source will be found if diligent search be made. The pulmonary vein is that most frequently involved, and it is so in about half the cases. In a case observed by the author, in which the primary tuberculosis affected the lung, a branch of the pulmonary vein, the size of a crow quill, presented in its wall an elongated, yellow, caseous layer, somewhat resembling a thin localized thrombus. The surface was smooth and there was no layer of fibrine between it and the calibre of the vessel which was here uninterrupted, except by the slight projection of the yellow mass. Tubercle bacilli were found in large numbers in this yellow structure, extending to its internal aspect. Bacilli were also found in the blood and in the miliary tubercles in lungs, liver, etc.

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Tuberculosis—Ponfick, Berl. klin. Wochenschr., 1877; Zahn, Virch. Arc lxxvi., 1879; Weigert, *ibid.*, vol. lxxvii., and Deutsch. med. Woch., 18 1885; Tripier, Arch. de méd. expérimentale, 1890; Benda (with lite Lubarsch and Ostertag, Ergebnisse, 1900.

TUBERCULOSIS IN ANIMALS.

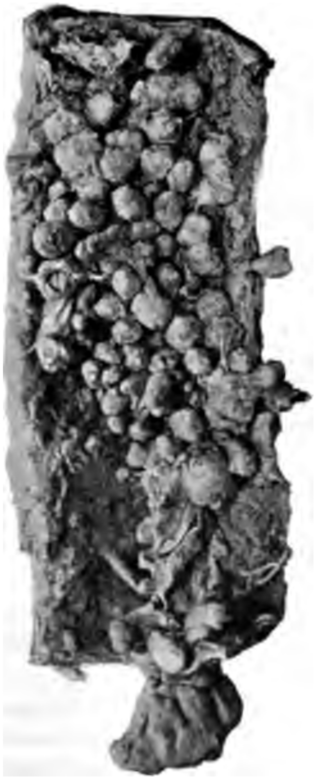

Fig. 72.—Bovine tuberculosis from the costal pleura of a cow. The nodules are sessile and pedunculated. Most are caseous and some are calcified.

It has been already mentioned that tuberculosis has been communicat large number of animals by inoculation, and that probably all warm- animals are susceptible. As a spontaneous disease it occurs in many d animals. In these the lesions observed are similar to those in man, consi tubercles formed of giant-cells and epithelioid cells with varying propor leucocytes. There are, however, certair variations in structure in certain a Bacilli presenting practically all the ch of the tubercle bacillus have been found affected structures. For practical purpc most important form is that which oc cattle.

Bovine tuberculosis.—Tuberculosis is ingly common in cattle. It is a suggest that, according to Nocard, in stall cattl eight or nine out of every ten are tube while among the young who have not y stalled there are eight, nine, or even ten every ten which are not tuberculous. facts were ascertained by the employn Koch's tuberculin to diagnose the diseas living animals. Considering the close between cattle and the food of man, regard to milk and butcher meat, the are very important.

The structures most frequently affec the serous membranes—the pleura an toneum especially—and the lungs, but the often extends to lymphatic glands, ali canal, liver, spleen, nervous system, etc. **serous membranes** the tubercles are ag into considerable nodules, frequently as lentils. They are attached to the surfac membrane or else supported on villous tions from the surface. (See Fig. 72.) may be massive projections of these hanging from the pleura or peritoneum. the size of the nodules and their white ance they have been compared to pearls, and the name **Perlsucht** has b in Germany for the serous form of the disease. In **internal organs** we h comparatively large rounded nodules, and sometimes considerable infiltrati

The nodules in bovine tuberculosis are peculiarly prone to **calcificatio** calcification is probably always preceded by caseation, but the latter may be so rapidly overtaken by the calcareous infiltration as to be masked.

We have seen that in Bovine Tuberculosis bacilli presenting practically all the characters of human tubercle bacilli have been found, and most observers, while cognizant of existing differences between them, have satisfied themselves that the two bacilli are virtually identical. Koch, however, has recently affirmed that human and bovine tuberculosis are practically distinct affections, that transmission of the disease from the ox to man is of very rare occurrence, and therefore that the precautionary measures in force with regard to milk and butcher meat are unnecessary. Koch bases his statement on the almost negative results obtained by him in inoculating cattle with human tubercle bacilli. Calves, he found, were practically insusceptible. From this he argues that the converse must be true, that inoculation of human beings with bovine tubercle bacilli will give similar negative results. In support of his views he gives it as his opinion that infection from the intestinal canal in the human subject is very rare. While it is an accepted fact that oxen are little susceptible to human tubercle bacilli they are not absolutely insusceptible, and several instances of successful inoculation are known. To accept the converse of this is much more difficult. Direct proof is naturally less easily obtained, but here also cases are on record which can only be regarded as instances of direct transference of the disease in oxen to man. We believe further that Koch has distinctly underestimated the frequency of infection from the intestinal canal in man. His statements have had the effect of directing very special attention to the subject, and we shall doubtless soon be in a position to judge whether our precautionary measures are necessary or the reverse. For the present there is no reason why they should be discontinued.

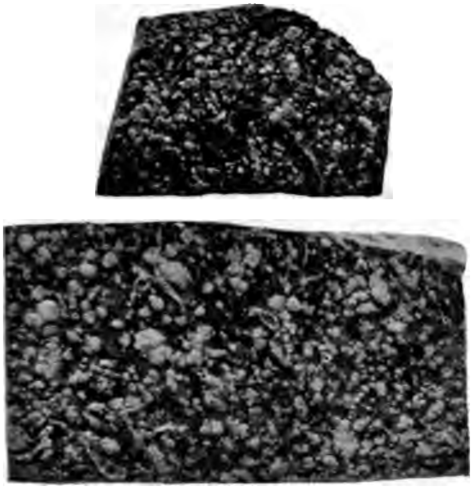

Fig. 73.—Tuberculosis of the lungs in a horse. The caseating nodules contain large numbers of tubercle bacilli.

Tuberculosis in horses somewhat resembles that in cattle, there being usually pearl nodules on the peritoneum. There may be also numerous nodules in internal organs, as, *e.g.* the lungs (see Fig. 73). These are more like those in human miliary tuberculosis. Tuberculosis in horses is said to be sometimes mistaken for sarcoma; it is not of common occurrence.

In swine tuberculosis is a frequent disease. It resembles bovine tuberculosis in its general characters as well as in its tendency to calcification.

Tuberculosis is very common **in monkeys**, in which animals it usually begins in the lungs, but is apt to extend to other organs in the form of chronic general tuberculosis, so as to form numerous comparatively large foci, which usually break down and produce cavities.

Tuberculosis in birds (avian tuberculosis).—This disease is due to a bacillus which closely resembles the ordinary tubercle bacillus, but differs in its appearance in cultures and in its virulence in different animals.

The microbe differs considerably in its pathogenic relations from that of mammalian tuberculosis, though it cannot be considered a distinct species. It is rather a variety which has become modified in the tissues of birds. Thus while fowls, and especially singing birds, are highly susceptible, they are comparatively immune to the organism of mammalian tuberculosis. It is possible, however, to inoculate fowls with tuberculosis by means of bacilli obtained from a mammalian source, the lesions produced being closely similar to, if not identical with, those produced by the organism of avian tuberculosis. On the other hand, the guinea-pig, which is so highly susceptible to infection with the tubercle bacillus, may also be infected with a tuberculosis in all respects typical by means of the organism obtained from cases of this affection in birds.

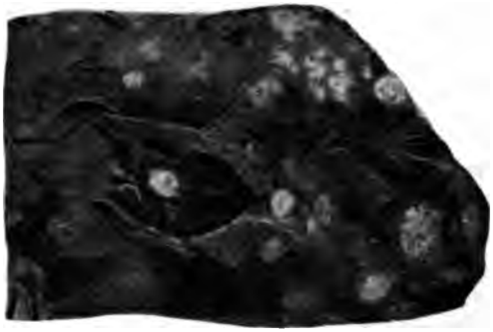

Fig. 74.—Caseous tubercles in the liver of a fowl.

The spontaneous disease in fowls is said to be transmitted congenitally (like syphilis), and the lesions are chiefly in the liver (see Fig. 74).

Recent observations go to prove that even **fish** may suffer from a disease which has the character of tuberculosis.

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III.—LEPROSY OR LEPRA.

This disease was at one time spread over the whole of Europe, but is now limited to certain localities in Norway, Russia, Iceland, and the coast of the Mediterranean. It is still somewhat prevalent in Asia, especially India, Japan, and China; in Africa, where it is very prevalent in Egypt, Abyssinia, and the Islands of the East Coast; and in America, especially in the West India Islands and Mexico. (See Hirsch.)

Causation.—The disease is regarded by some as hereditary, but a considerable number of cases of contagion have been observed.

The **question of contagion** as a cause of leprosy has been till lately an undecided one. But recently several cases of communication to Europeans, evidently by contagion, have been published, one in which it was communicated by vaccination. A final demonstration of contagion has been furnished by the inoculation of a condemned criminal at Honolulu by Dr. Arning. The inoculation was successful, but the period of incubation was very prolonged. It is probable that the incubation may extend over several years, and if this be so, it will be frequently very difficult to trace the source of contagion. The reality of contagion has received its final demonstration in the case of Father Damien, a Catholic priest who ministered to a leper colony and contracted the disease, of which he died in 1889. The researches of Thin seem to show that leprosy was introduced into Italy about the time of Christ, and that it spread thence into the countries of Northern and Western Europe. Within a few centuries it had spread to such an extent and excited such disgust and terror, that the populations were roused to drive the lepers from their midst. They were now gathered into 'lazar-houses,' and otherwise isolated. With the adoption of these measures leprosy began to disappear, and soon became almost extinct in the principal countries of Europe.

Bacillus lepræ.—The bacillus of leprosy was first observed by Hansen in Norway in 1871, and the observation has been confirmed by Neisser and many others. It is a rod which closely resembles the tubercle bacillus, and, like it, is motionless. It presents clear spots, which remain uncoloured when the bacillus is stained, but it is not known whether these are spores or not. It is stained by the same process as the tubercle bacillus, but does not resist decolorization so strongly, and it is stained by concentrated watery solutions of the aniline dyes, especially fuchsine and methyl-violet, somewhat more readily than the tubercle bacillus.

The bacillus is found in all cases of leprosy in the lesions in the skin, mucous membranes, nerves, and elsewhere. It occurs in very large numbers, especially in the tubercular form, so that when stained by Gram's method a section will have a decided blue colour from the stained bacilli alone. It presents itself partly free in the tissues, but mainly in the interior of round cells (the lepra cells of Virchow) which are considerably larger than leucocytes. (See Fig. 75.) These cells are to some extent the endothelium of the vessels, but other fixed connective-tissue cells apparently act as phagocytes to the leprosy bacillus. The bacilli are so numerous as to suggest that the characteristic cutaneous swellings may be in part due to the actual bulk of the bacilli.

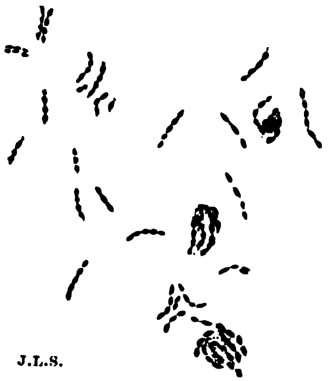

Fig. 75.—Leprosy bacillus. Those in groups are inside cells.

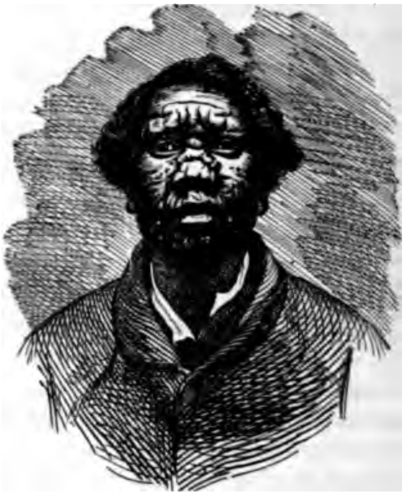

Fig. 76.—Leprosy. The face shows nodular swellings, especially on nose, eyebrows, lips, chin, and ears. Patient had also a large ulcer on right leg, and a small one on left. (VIRCHOW.)

Numerous attempts have been made to cultivate the bacillus, but hitherto without success. Melcher and Ortmann have succeeded in inoculating the anterior chamber of the eye in rabbits with pieces from a freshly excised leprosy nodule. Characteristic new-formations appeared in almost all the internal organs, especially the cæcum, lymphatic glands, spleen, and lungs. In these the bacilli were said to be abundantly present. In man there is the successful case of inoculation referred to above.

Character of the lesions.—The disease occurs in two forms which are designated **Lepra tuberculosa** and **Lepra anæsthetica.** In the first the new-formation has its seat in the skin or mucous membrane; in the second it is the nerves which are affected. The tubercular form is sometimes called **Elephantiasis græcorum.** Frequently the tubercular and anæsthetic forms occur in the same patient (**Mixed Leprosy).** In both forms the onset of the symptoms is characterized by general constitutional disturbance in the form of malaise and frequently fever,

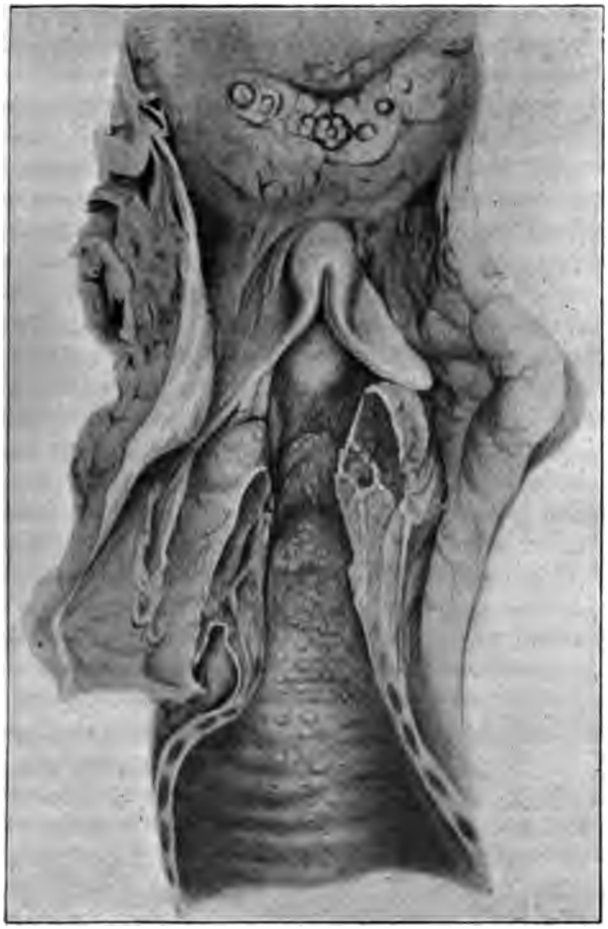

Fig. 77.—Leprosy of the Larynx and Trachea. There is marked infiltration of the epiglottis and ary-epiglottic folds, and numerous small nodules stud the mucous membrane of the trachea. Leprosy bacilli are present in enormous numbers.—Path. Mus., Univ. Coll., Dundee.

along with an erythematous eruption of the skin. These symptoms are more pronounced in tubercular leprosy than in the anæsthetic form, hich may be very insidious in its onset. Their occurrence would ndicate that the infection is present in the blood, and would make the phenomenon of leprosy analogous to the second stage of syphilis. This analogy is further borne out by the symmetrical character of the lesions, which are described below. The bacillus has only occasionally been found in the blood, and its position and condition during the long period of incubation are quite obscure.

Tubercular leprosy (*Lepra tuberculosa*) occurs mainly in the skin, but extends also to mucous membranes. After the acute symptoms referred to above, the erythema, which is a general eruption, passes off, and the permanent lesion limits itself, for the most part, to the exposed parts of the body. The skin of the face and hands are the parts most affected (see Fig. 76), and the legs if they are exposed. Of the mucous membranes, those of the mouth and larynx are often involved. (See Fig. 77.) The disease also extends to the lymphatic glands. In the skin there appear larger or smaller swellings, at first red or bluish in colour which become firmer and harder. These tubercles may reach the size of a hazel-nut or a walnut. They ulation tissue in which cells of various sizes have

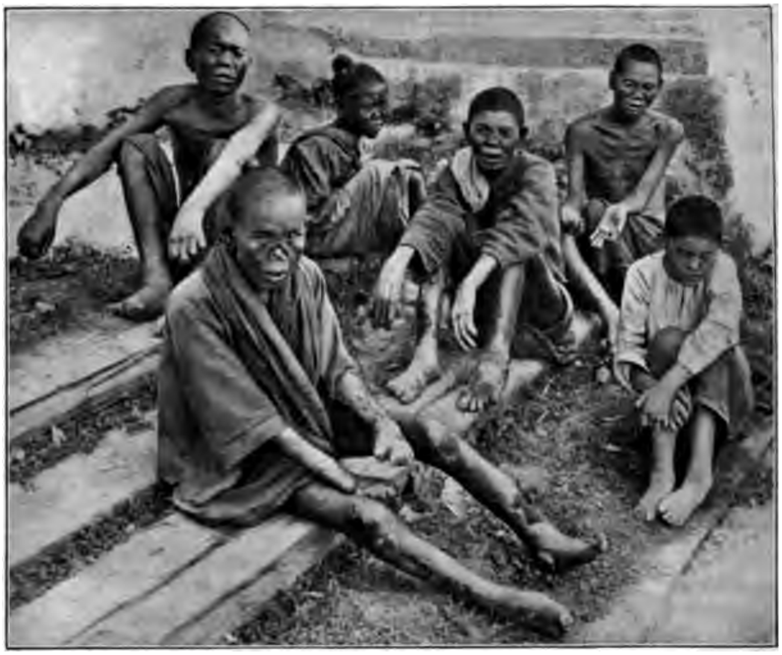

Fig. 78.—Leper group, Burma. The facial deformity with loss of the bridge of the nose, discoloration and ulceration of limbs, and loss of fingers and toes are shown. The central figure was almost entirely blind and aphonic.

replaced the cutis vera. These cells contain the bacilli. As in other granulation tumours, we often have ulceration, or, as in the case of lupus, there may be cicatrization without ulceration. By the formation of the swellings and cicatrization, great deformities frequently result, so that the patients have often a peculiarly hideous appearance, the face being knobbed and gnarled (Fig. 76).

Nerve leprosy (*Lepra anæsthetica*) is characterized by the stems of the peripheral nerves becoming the seat of spindle-shaped swellings, sometimes of considerable length. The granulation tissue here is in the interstitial connective tissue, so that the nerve-fibres are separated and compressed. The new-formation sometimes, but rarely, extends to the membranes of the spinal cord or brain.

The nerve affection leads to neuralgias and to conditions of the skin which are related to the interruption of the conductivity of the nerves. Localized patches of anæsthesia occur. There are patches in which the colour varies, being darker or paler than normal (**Macular leprosy**). In the older patches, the central parts are mostly pale (white leprosy). Deep ulcerations sometimes follow, not infrequently leading to separation of the fingers or toes. (See Fig. 78.) No bacilli have been found in these peripheral lesions; they are simply the result of the interference with the nerves.

In leprosy there are sometimes tumours formed in internal organs, but this is rare. Microscopic lesions in the liver, spleen, testes, etc., are not uncommon.

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IV.—ELEPHANTIASIS ARABUM.

This disease, which is called elephantiasis arabum to distinguish it from E. græcorum, which is true leprosy, is often simply designated Elephantiasis, sometimes also **Pachydermia.**

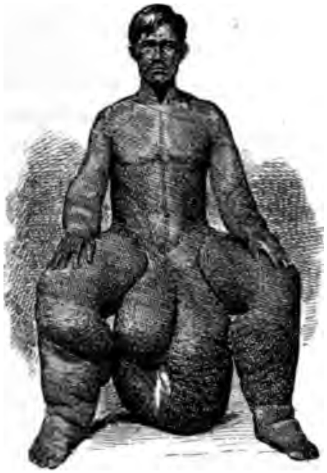

Fig. 79.—Elephantiasis affecting scrotum, legs and arms. (After photograph by TURNER.)

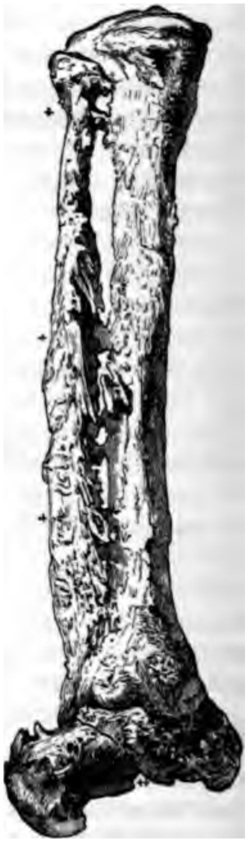

Fig. 80.—Hyperostosis and synostosis of the bones of the leg and foot in elephantiasis. The bones present everywhere flat or pointed projections. At + + + the tibia and fibula are united, as they are also above the ankle-joint. The astralagus and os calcis are also united. (VIRCHOW.)

Causation.—The disease is endemic in certain localities in India, China, Egypt, Arabia, the islands of the Pacific, etc., chiefly in places within a short distance of the sea. It obviously depends on some [illegible] but the nature of it has not been discovered. The [illegible] acute inflammation of the skin, accompanied by fever, and somewhat resembling erysipelas. These attacks pass off and recur, the disease ultimately subsiding into a more chronic condition. These are conditions which can only be produced by a morbid poison acting on the tissues locally and probably sending off products into the blood so as to induce fever. The fact that no secondary lesions occur at a distance is an indication that the virus itself does not reach the blood. The disease attacks chiefly the native races, but no race is exempt from it. Sporadic cases are met with occasionally.

Character of the lesion.—The lesion consists of an enormous hypertrophy of the tissues of the skin. The cutis vera is thickened, the papillæ are enlarged, and the epidermis is thickened. In the earlier periods the new-formed tissue is somewhat cellular, and throughout it is succulent and œdematous. The disease occurs chiefly in the lower extremities and external genital organs, but sometimes attacks the upper extremities. In the lower extremities it produces an extraordinary irregular thickening of the skin, which has a folded and bagged appearance, like that of the legs of an elephant. (See Fig. 79.) In the genital organs it produces tumours which sometimes grow to a massive size; tumours have been excised which weighed over 100 pounds, and which hung down so as to reach below the knees. (See Fig. 79.) Sometimes the tumour is not entirely made up of hypertrophied skin, but a definite isolated tumour is found internally. This was so in a case observed by the author. In the legs the new-formation may extend inwards to the fasciæ, the inter-muscular tissue, periosteum, and bone. The accompanying Fig. 80 shows how the bone may be the seat of new-formation.

Sometimes there is great dilatation of the lymphatic vessels. It is asserted that the disease may develop from so-called lymph-scrotum, and Manson has inferred that elephantiasis, like lymph-scrotum, depends on the filaria sanguinis. (See under Parasites.)

Occasionally localized cutaneous enlargements are met with, which in some respects simulate elephantiasis. They have been grouped by Hutchinson under the title of Elephantoid hypertrophies (see under Tumours).

Literature.—Manson, Allbutt's Syst. of Med., ii., 1897, and Tropical Diseases, 2nd edition. 1900; Virchow, Geschwülste, vol. i.; Esmarch und Kulenkampff, Die elephantiastischen Formen, 1885; Carter, On Leprosy and Elephantiasis, 1874; Turner, Amputation of scrotum for Elephantiasis, Glas. Med. Jour., 1882, vol. i. (with photographs).

V.—GLANDERS.

This disease is met with chiefly in horses, but is occasionally communicated to man. The name **Farcy** is sometimes given to the disease when the skin and lymphatic system are specially affected.

Causation.—The disease has been shown by Loeffler and Schütz to depend on a bacillus which resembles the tubercle bacillus in form but requires different methods of staining. The bacillus is present in large numbers in the lesions of glanders, is readily cultivated, and easily communicated to animals.

The bacillus is a rod about the size of the tubercle bacillus, but slightly thicker. It is generally slightly curved, and usually single or in pairs. It is not motile, and it is not certain that it produces spores.

It may be stained with the ordinary aniline dyes, especially with fuchsine, but better results are obtained with Loeffler's methylene blue or carbol-thionin. The organism is completely decolorized by Gram's method.

The bacilli may be cultivated on most of the ordinary media, on agar and glycerin-agar they give a whitish-grey, somewhat translucent culture. On potato there is a very characteristic growth, at first amber coloured, then becoming darker till it assumes a reddish-brown or red tint with a yellowish-green colour peripherally. A temperature between 25° and 42° C. is necessary, the best results being obtained between 30° and 40° C.

Animals are readily inoculated, but there are peculiar differences in susceptibility. As the disease is mainly one of horses, it is natural to find that these animals and asses are readily affected. Field mice and guinea-pigs are also readily affected, but white mice, house mice, pigs, and cattle hardly at all. There is always a local action at the point of inoculation, from which there may be a gradual extension, but not by the blood.

In man an accidental infection sometimes occurs, resulting in local abscesses, with secondary extension to the mucous membranes, joints, etc.

A remarkable fact is, that in cultivating the bacillus, it gradually loses its infective power, so that in the fourth or fifth generation it has become so harmless that it is necessary to inoculate much larger quantities, and the effect is merely local. By further cultivation the bacilli lose their virulence.

From the cultures the substance **Mallein** is obtained. The cultures are usually grown for some weeks in glycerin bouillon. They are then sterilized by heat and filtered. The filtrate is mallein. This substance, like tuberculin, is much employed by veterinary surgeons as a diagnostic agent.

Character of lesion.—The disease in horses manifests itself first in the formation of swellings of the mucous membrane or skin, consisting of granulation tissue. The nasal mucous membrane is generally first attacked, and there is either a diffuse infiltration of it or else a more localized series of swellings like those of lupus (see Fig. 81). From this seat the disease spreads to neighbouring lymphatic glands, also along the mucous membrane to the lungs and intestinal tract. The skin also becomes the seat of lesions.

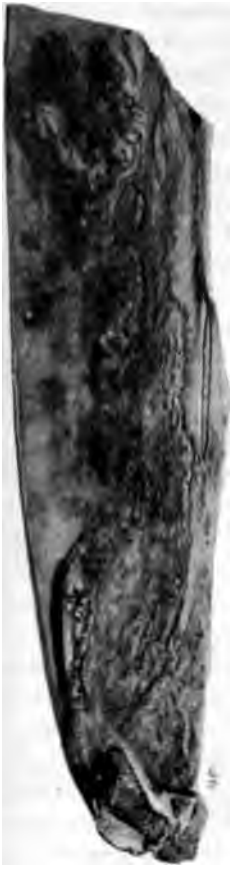

Fig. 81.—Nasal septum of horse in glanders.

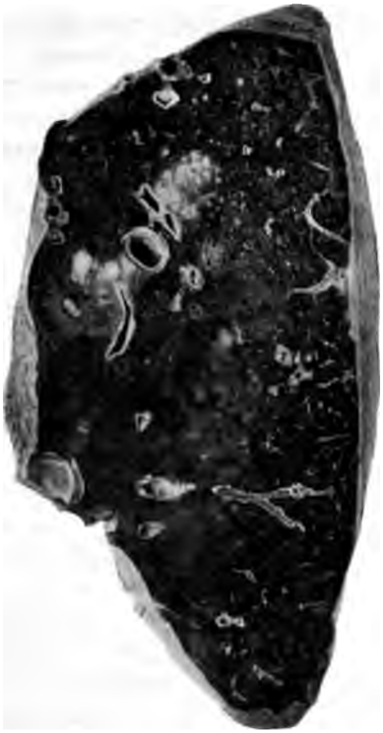

Fig. 82.—Portion of the lung of a horse in glanders. Two considerable nodules are shown in the upper part of the illustration. Centrally the lung tissue is consolidated.

The granulation tissue here, even more than in the other infective tumours, tends to break down, so that, as a rule, ulcers soon form, which present a great tendency to spread. These ulcers arise by what is virtually a suppurative process, and if the tumours are situated deep in the skin or mucous membrane there may be actual abscesses, which, by bursting, form ulcers. If the ulcers heal, cicatrices are formed in the usual way.

The manifestations in internal parts are largely inflammat character. The lymphatic glands of the neck are the seat of i matory swelling. In the lungs there are nodules either consist granulation tissue with caseous central parts, or more distinctly monic (see Figs. 82 and 83). There are also in the mucous mem of the intestinal canal nodules which are sometimes solid, at other breaking down into pus.

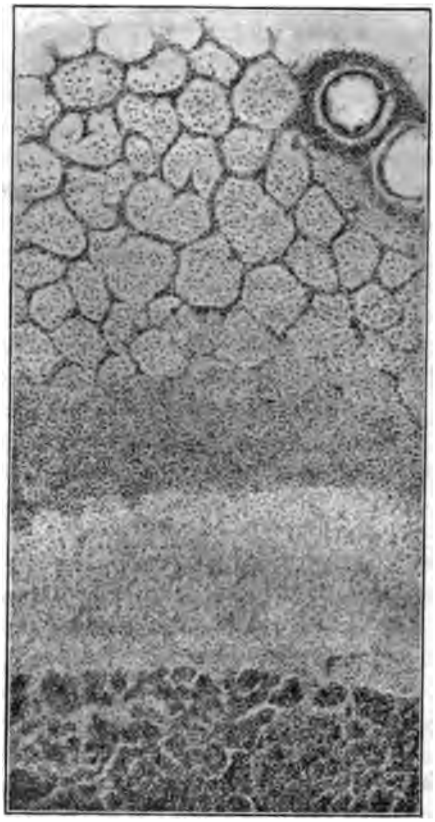

Fig. 83.—Margin of a glanders nodule in the lung of a horse. In the lower par towards the centre of the nodule there is a dense aggregation of leucocytes. The are less abundant at the periphery. The lung alveoli contain catarrhal cells. × 40.

The above description applies to the acute cases, which ar commoner, but the disease is sometimes chronic in its course. Cl cases have usually the nodules in the skin, and there are seco tumours in the muscles, etc.

In man, glanders, which occurs occasionally in persons en *about* horses, is usually an acute, rapidly fatal disease. Ther nodules and ulcers in the mucous membranes and the skin, and frequently phlegmonous inflammation of the skin with abscesses among the muscles, etc. In fact, in man the disease takes the inflammatory character more distinctly than in the horse. We may have in man also nodules, ulcers, and abscesses in internal organs. Sometimes the abscesses in the lungs, kidneys, etc., cause the disease to resemble pyæmia. At other times the juices from the ulcers in the nose or mouth being inhaled, may give rise to lesions like those of phthisis pulmonalis.

Chronic glanders in man is characterized by ulcers in the mucous membranes of the fauces, bronchi, etc., and in the skin. There may be caseating nodules in internal organs.

Literature.—VIRCHOW, Geschwülste, vol. ii.; BOLLINGER, Ziemssen's Handb., vol. iii.; LOEFFLER und SCHÜTZ, Deutsche med. Wochenschr., Dec., 1882; M'FADYEAN and WOODHEAD, Report, National Vet. Assoc., 1888; BONOME, Deutsch. med. Wochenschr., 1894; FRIEDBERGER and FRÖHNER, Lehrbüch, ii., 1896.

VI.—ACTINOMYCOSIS.

This disease is prevalent in oxen in whom it was first recognized as parasitic by Bollinger. Less frequently it is met with in horses and swine. It has been observed in man in a considerable number of cases, and would appear to be readily communicable.

Causation.—The disease is due to a parasite which was named by Bollinger **Actinomyces** or **Ray fungus**, but more recent observations have shown that the organism does not belong to the class of fungi proper, but rather to the higher bacteria. It is now usually placed in the streptothrix group. The ray form, further, is only one of the forms which this pleomorphous microbe may assume, and it is the one seen most characteristically in the tissues of affected animals. It has been likened in appearance to the head of a daisy, a large number of short threads radiating as from a common centre, with swelling or clubbing of the free extremities (see Figs. 84 and 85). In the tissues of man the clubbing of the extremities is less easily made out, the appearance being more of a tangle of branching filaments which radiate out from a central matted portion (see Fig. 85). Small spherical bodies like cocci are also commonly seen. These are regarded by some as gonidia. The filaments and spherical bodies are readily stained by Gram's method. In the actual lesions, especially in animals, the microbe is surrounded by giant cells, and these often enclose portions of the parasite. They are indicated in Figs. 84 and 85. The little masses thus form peculiar radiating bodies of a globular or oval form, having a somewhat glandular aspect. The individual clumps are of very small size, not visible to the naked eye, but they may be united into larger masses, as the heads in a cauliflower. These larger masses appear as small transparent or opaque yellowish or greenish grains in the discharges of new-formations.

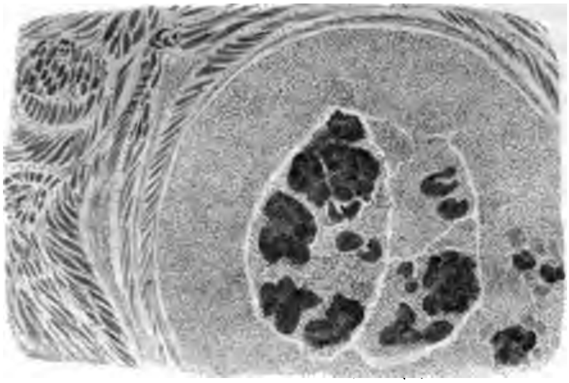

Fig. 84.—Actinomycosis. Tongue of cow. Colonies of actinomyces are seen.

The microbe is readily cultivated on ordinary media, the best results being obtained at a temperature of 33° to 37° C. The cultures show filaments, shorter threads or rods, and cocci, the ray form being regarded by some as only occurring when the soil is unsuitable for perfect growth. The microbes have been successfully inoculated into cattle and into the abdominal cavity of rabbits and guinea-pigs.

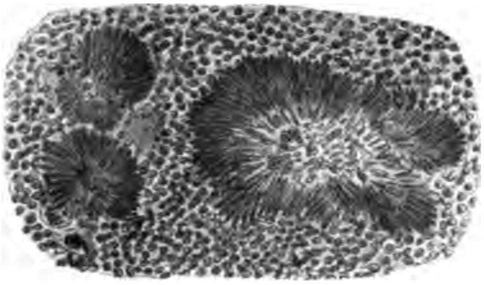

Fig. 85.—Actinomycosis. From same case as Fig. 84.

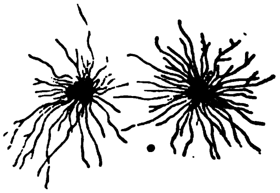

Fig. 86.—Actinomycosis. From urine. Filamentous form.

Character of lesion.—Whether in animals or man each fungus-head constitutes a centre of irritation, and granulation tissue forms around it. By coalescence there are formed bulky masses of granulation tissue. There is no tendency to caseation, but rather to the formation of pus on the one hand and cicatricial tissue on the other. The disease usually presents itself in cattle in the form of bulky round tumours, which are mostly in the neighbourhood of the jaws, but may be in any part of the body. The indurated or Wooden Tongue of cattle is one of its commonest manifestations (see Fig. 87). These tumours usually contain a yellow pus in which, and in the granulation tissue which lines them, the parasite is readily found. In man there is a more extended formation of granulation tissue, and more of a suppurative character (see Fig. 88).

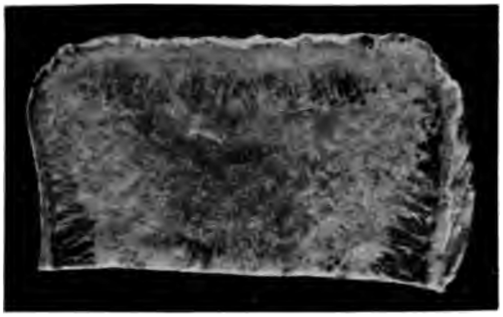

Fig. 87.—Actinomycosis affecting the tongue of a cow. A dense white tissue invades the muscle. Immediately under the mucous membrane of the dorsum numerous colonies of actinomyces were found.

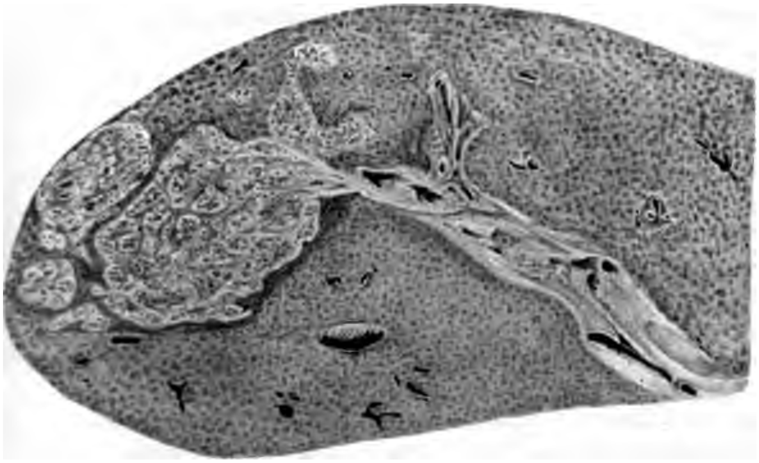

Fig. 88.—Actinomycosis in human liver. Section of part of an extensive lesion which penetrated the capsule of the liver. Closely aggregated purulent foci in the midst of firm granulation tissue are shown. The honey-comb like appearance is characteristic.

The microbe seems to find entrance chiefly through the mouth, and the disease has its primary seat about the jaws, in the respiratory tract, or in the alimentary canal.

In **Actinomycosis of the face and neck**, the fungus has obtained entrance by breach of surface in the mouth, usually in connection with carious teeth, so that the commencement is usually in connection with the jaw. There is a formation of granulation tissue around the jaw, usually the inferior maxilla, extending to the parts around. The process is a chronic one, and by degrees the lesion extends to the surface. Abscesses form which discharge and leave fistulous openings. Sometimes the new-formation extends to the vertebræ or base of the skull, especially when the upper jaw has been the starting point.

The respiratory organs may be the primary seat. There may be a superficial actinomycosis, producing simply a suppurative bronchitis. More usually the fungus is in the substance of the lung, giving rise to chronic condensations and indurations in isolated patches. These enlarge and coalesce, and they often break down so as to form cavities. The process is a chronic one and somewhat resembles that in phthisis pulmonalis, but differs in respect that it does not usually attack the apices of the lungs. The disease is apt to involve the pleura and the neighbouring pericardium. It not infrequently extends to the bodies of the vertebræ, causing them to become carious. There is here a slow inflammatory process with exuberant granulations and suppuration. The abscess may reach the surface by a course similar to that of a tubercular abscess of bone.

The alimentary canal is more rarely the primary seat of actinomycosis. The vermiform appendix is not infrequently primarily affected. There are nodules and ulcers formed and the disease extends to the peritoneum, leading to the formation of granulation tissue and abscesses in the cavity of the peritoneum. There may be perforation of the bladder, intestine, or abdominal wall. Secondary extension to the liver is common in primary actinomycosis of the alimentary canal (see Fig. 88).

Madura Foot or Mycetoma.—The position of the disease called **Mycetoma** and **Madura foot** is not yet completely determined, but all recent evidence points to the great probability that it is a separate and distinct disease, allied to Actinomycosis. Carter asserted that a fungus was the cause of the disease, and the name Chionyphe Carteri was given to the fungus. Kanthack more recently described and figured a fungus which he asserted to be a form of Actinomyces. Boyce and Surveyor hold that this fungus is only present in the **pale** or **ochroid** form of the disease and that a large branching septate fungus, a hyphomycete, is present in the **black** or **melanoid** variety. The observations of Wright are confirmatory. The more recent observations of Vincent on a case of the pale variety seem to show that the parasite is not actinomyces, but a form resembling this which he designates **Streptothrix maduræ.** He has cultivated it on various media and finds that its behaviour differs from that of actinomyces. It thus seems clear that a different organism is present in the two forms of the disease.

The disease is characterized by the presence of canals and cavities which penetrate both the soft parts and the bones. These open externally and discharge a fluid which contains black granules in the black form, and yellow granules resembling fish-roe in the pale form. On dividing the foot the passages are visible; in the black form they contain dark-coloured debris and in the pale form granules like those discharged. There is great thickening of the parts and an appearance resembling tubercular disease. The condition is a chronic one, for which amputation is frequently performed.

In some cases the fungus gets into the blood and is disseminated in various organs. In that case there are abscesses produced, and the disease is like a **chronic pyæmia.**

Literature.—Bollinger, Centralb. f. d. med. Wissensch., 1877, No. 27; Ponfick, Die Actinomycose des Menschen, 1882; Israel, Actinomycosis in man, Syd. Soc., 1886; Shattock, Path. trans., vol. xxxvi.; Acland, ditto, vol. xxxvii. An exhaustive account of Actinomycosis is given by Bostroem in Ziegler's Beiträge, vol ix., 1891. *Madura foot* or *Mycetoma*—Carter, Mycetoma or the fungus dis. of India (with coloured plates), 1874; Lewis and Cunningham, Fungus dis. of India, 1875; included also in Lewis's Physiol. and pathol. researches, 1888; Moxon and Hogg, Path. trans., 1869, p. 411; Kanthack, Journ. of Path., i., 140, 1892; Hewlett, Lancet, ii., 1892; Boyce and Surveyor, Proceedings of Royal Soc., 1893; Vincent, Ann. de l'Inst. Pasteur, viii., 129, 1894; J. H. Wright, Journ. of Exper. Med., iii., 421; Acland (bibliography), Allbutt's Syst. of Med., i., 1897; Ruhräh (literature), Annals of Surgery, xxx., xxxi., 1899-1900; Schlegel (literature), Lubarsch and Ostertag, Ergebnisse, 1900; Dean (streptothrix), Path. Trans., Lond., li., 1900; Foulerton and Price-Jones, ditto, liii., 1902.

VII.—HODGKIN'S DISEASE.

The exact relations of this disease, or group of diseases, are somewhat obscure. In many respects it presents the characters of the infective tumours, and hence is included here. On the other hand it is related to leukæmia, this latter disease sometimes presenting most of the organic lesions of Hodgkin's disease. According to some observers a certain number of cases terminate in leukæmia. By some leukæmia is also included amongst the specific new-formations. The uncertainty as to the nature of the disease may be inferred from an enumeration of the names applied to it. Besides the above we have **Adenia, Pseudo-leukæmia, Lymphosarcoma, Malignant lymphoma, Malignant lymphadenoma, Malignant aleukæmic lymphadenoma**, and **Anæmia lymphatica**. The disease is accompanied by marked anæmia and dropsy, but there is practically no increase of leucocytes in the blood, thus forming a marked contrast with leukæmia. Fever is present in some cases. The cause or causes which produce Hodgkin's disease are as yet quite unknown.

We include here cases in which there is first an enlargement of a group of glands, and a subsequent extension to other groups, followed in many cases by a further extension to the spleen and liver, and even to other structures. This is the disease described by Hodgkin and properly designated by his name. It is an infective disease, having some analogies with tuberculosis, but limiting itself much more to the lymphatic system.

The disease begins with a local enlargement of a certain group of lymphatic glands, frequently those of the neck, but it may be those of other situations, such as those of the axilla and those accompanying the thoracic and abdominal aorta. Beginning in one set it is liable to extend to others till there may be a widely-extended enlargement of the glands in many regions. The affection of the glands consists in a proliferation of the lymphatic gland tissue. The enlarged glands may be of the same consistence and appearance as the normal glands, but they may be softer or harder. There is not infrequently a trace of caseation in the glands, especially when they are hard. In the soft form the new-formation may extend beyond the boundaries of the glands and invade surrounding parts.

The **spleen** is affected in most cases of Hodgkin's disease, although not in all. It is enlarged, and its outline shows localized elevations as if there were distinct tumours present. On section, however, these have not the appearance of definite separate growths, but rather of localized infiltrations of the splenic tissue. There are areas of yellowish white appearance, which have been compared to lumps of suet in a pudding. Under the microscope it is seen that in these areas the tissue is lymphatic, consisting of round cells with a reticulum like that in lymphatic glands. Moreover, the tissue arises by proliferation of the lymphatic follicles of the spleen (the Malpighian corpuscles) which normally accompany the splenic arteries. The **liver** is also commonly affected, there being here an infiltration of the capsule of Glisson, such as occurs in some cases of leukæmia. The **kidneys** also in some cases show in their external configuration rounded swellings, which are due to localized infiltrations of round-cells. There may also be enlargements of lymphatic structures other than those of the lymphatic glands and spleen, such as the closed follicles of the intestine, the tonsils, etc. The bone marrow may show changes.

Hodgkin's disease may give rise to amyloid degeneration, as in a case observed by the author. In this case a sago spleen was the seat of secondary lymphatic new-formations. The new-formation occupied the same structures as the amyloid disease, and it was interesting to observe how the round-cell infiltration caused absorption of the amyloid material, and how the arteries, whose walls were amyloid, recovered their structure under the influence of the new-formation.

It is proper, as Steven has pointed out, to distinguish Hodgkin's disease from **lympho-sarcoma.** The former has more the characters of a general disease of the lymphatic system, originating locally, but spreading in the lymphatic system. The latter is a local disease of a certain group of glands, usually the mediastinal ones, and showing chiefly a local malignancy.

Granuloma fungoides (*Mycosis fungoides*) is referred to under Diseases of the Skin.

Literature.—HODGKIN, Med. Chir. trans., 1832; WILKS (who suggested the name Hodgkin's disease, and has chiefly brought it into prominence), Guy's Hosp. Reports, 3rd series, vols. ii. and xi., also cases in Path. trans.; MURCHISON, Path. trans., xxi., 372; also papers by WILKS, GREENFIELD, and others in Path. trans., xxix., 1878; HILTON FAGGE, Medicine, 1886, vol. ii., 334; STEVEN, Glas. Med. Jour., vols. xxxv. and xxxvi., 1891; FLEXNER, Johns Hopkins' Hosp. Rep., 1893: DIETRICH, Beiträge z. klin. Chir., xvi., 1896; MURRAY, Allbutt's Syst. of Med., iv., 1897.

SECTION VI.

INTOXICATIONS—DISEASES RESULTING FROM CHANGES IN SECRETION AND EXCRETION.

Intoxications.—A varied assortment of morbid conditions characterized by changes in the blood and other fluids, either from the presence of toxic substances or from alterations in chemical composition. A. *Intoxication.* Definition. **Auto-intoxication.** Limitation of term. B. *Diseases from changes in secretion and excretion.* (1) Uræmia. (2) Gout. (3) Diabetes. (4) Lipæmia. (5) Melanæmia. (6) Myxœdema. (7) Cretinism. (8) Exophthalmic goitre. (9) Acromegaly. (10) Addison's disease.

THE progress of observation has brought together conditions which formerly were regarded as widely separated, and in the present section we have a somewhat varied assortment of morbid conditions. They are all characterized by changes in the blood and other fluids of the body, either by the presence of toxic substances or by alterations in the chemical composition of the plasma. The body as a whole is affected by the altered conditions of the nutritive fluid, and, in this sense, the term **Constitutional Diseases** is applicable. This group of diseases is at the present time the subject of much investigation and research. It must therefore be understood that the terminology and classification are, to a large extent, tentative. There is considerable over-lapping amongst the members of the group themselves and with conditions belonging to other groups.

A. INTOXICATION—AUTO-INTOXICATION.

Intoxication means the action on the living elements of the tissues of substances which affect the intimate vital chemistry of these elements. In this sense it has wide relations and is frequently an incident, but always an important incident, in a variety of diseases. Intoxication includes mere **Poisoning**, or the introduction of toxic substances from without, but that group of conditions does not concern us here. Again, almost all **Infections** are accompanied by intoxication, this being, in many cases, the most significant phenomenon of the disease. Excluding this group of conditions from our present review, there remain certain phenomena which are not the effect of poisons intruded as such nor of toxins produced in the body by infective agents. To this group the term **Auto-intoxications** is applied.

Auto-intoxication is a term the use of which is by no means strictly defined. As it implies an intoxication of the body by itself, it may properly be limited to the production of poisons either in the metabolism of the tissues or in the course of processes which belong to the ordinary or normal functions of the body.

The elaboration of poisons in the regular **metabolism of the tissues** has been the subject of investigation by the French school and especially by Bouchard. The alkaloids thus produced are designated **leucomaïnes**, which are distinct from alkaloids arising from putrescence of albuminous tissues or **ptomaines**. Extracts of normal tissues, more especially muscle and liver, afford poisons, which, introduced into animals, produce symptoms which may end in death. Again, it has been pointed out that the urine contains poisons, and that the amount and character of these poisons vary greatly under different circumstances. The amount is considerably increased, for example, in fatigue, a fact indicating that, in the action of the muscles, there is a considerable production of leucomaïnes. The toxicity of the urine, no doubt, has various sources, but its existence may serve to show that the blood contains, under normal conditions, poisonous matters.

The **intestinal canal** is, under normal conditions, the seat of a variety of fermentations—some of them connected with the ordinary process of digestion, gastric or intestinal, some of them connected with the action of microbes which may have a useful effect in breaking up certain chemical combinations of the food, but which also produce various products of an offensive or injurious character. There must be variations in both forms of fermentation, and it may be presumed that defect in the proper digestive fermentations will give greater opportunity to the bacterial forms. The products of the bacterial fermentations are doubtless absorbed, and they frequently proclaim the fact by the evil odour of the breath and other exhalations. It must be regarded as undecided to what extent the symptoms of **dyspepsia** are due to an auto-intoxication produced in the way indicated or by reflex nervous influences, but certainly the deranged chemical processes and the absorption of various products of putrefaction play some part in the symptomatology. It is stated that the toxicity of the urine is increased in the course of digestive disorders.

Whilst dyspepsia or mere constipation may increase the products of ordinary putrid decomposition in the intestine, there may, in some cases, be extraordinary fermentations set up. Gastro-intestinal catarrhs are sometimes accompanied by fever, and in this case there is either a very excessive absorption of the products of ordinary fermentation or the introduction of a special kind. Probably the latter is the case, and the condition passes beyond the strict limits of auto-intoxication. There are some who would include such cases in the term, and would even extend it to infections such as cholera, where a special microbe leads to the production of very specific poisons, but such an extension of the term is undesirable.

The liver has had an important part assigned to it in relation to gastro-intestinal auto-intoxication. By certain French writers it is asserted that the liver is the destroyer of toxic matters which are normally absorbed from the intestine. As the alimentary canal is constantly the abode of foul materials, these cannot fail to be absorbed, and it is a function of the liver, in receiving all the blood coming from the intestine, to destroy the poisonous matters, and prevent their entrance into the general circulation. To what extent the liver exercises this function cannot be said, but the view is apt to receive too ready an assent from its apparent support of the popular view that derangements of the liver have to do with many of the lighter ailments of mankind. It is an exaggeration of this view to suggest that the symptoms of acute yellow atrophy (icterus gravis) are in large measure due to the alimentary poisons reaching the circulation, on account of the elimination of the function of the liver.

B. Diseases from Changes in Secretion and Excretion.

As indicated above there may be an auto-intoxication from the retention of the excreta, more particularly those eliminated by the kidneys. Whilst the normal metabolism of the tissues produces leucomaïnes in small amounts which are promptly excreted, there may be, on the one hand, an increased production, and, on the other hand, a defective excretion. A third contingency has to be added, namely, an alteration in the process of metabolism. These various conditions give rise to different forms of disease.

1. **Uræmia.**—By this term is meant the poisoning of the body by the urinary constituents, which, by reason of their defective secretion or elimination, accumulate in the blood. As the condition is directly connected with disease of the kidneys and urinary apparatus it is more fully considered under that heading.

2. **Gout.**—In this condition an excess of uric (or lithic) acid in the form of urate of sodium is present in the blood and fluids of the body, and is deposited in a solid (mostly crystalline) form in the articular cartilages and elsewhere. The primary fact is the excess of urates in the blood, a condition which has been called variously **lithæmia** and **uratæmia,** and this excess may be very considerable. Whilst in normal blood traces of urates may be found by elaborate analysis, in gouty persons urates can be readily detected in the blood serum or blister fluid. This is done by acidulating the fluid, placing a few linen fibres in it, and leaving it in a warm place to evaporate, when crystals of uric acid will be found adherent to the threads.

The explanation of the excess of urates is not that of an accumulation from defective excretion as in the case of uræmia. The kidneys are indeed frequently involved, but this is often secondary, and there are many cases of gout without any disease of the kidneys. The excess seems due to a defective metabolism by which urates are produced in excess, and this again has mostly a constitutional origin. Inheritance plays a great part in the causation, and, consistently with the general facts of heredity, it is a defect in the finer adjustments of the bodily organization. Besides the hereditary predisposition, diet plays an important part in the causation, an excess of animal food, and of alcohol, more particularly in certain of its forms, being prominent factors. Lead poisoning is by many regarded as concerned in the causation, but it appears that it is so only when hereditary predisposition is pronounced (Roberts).

The excessive production of urates occurs in paroxysms, these being determined mostly by irregularities in diet. The paroxysm culminates in a deposition of solid urates, usually accompanied by great pain in certain joints. According to Roberts, the normal status of uric acid in the body, that is, in the blood, fluids, or urine, is that of a quadriurate. This form is readily soluble in presence of a soda salt, but it is a somewhat unstable compound. On the other hand, it is a biurate which is found in gouty deposits, and this is very insoluble in solutions containing soda. It is suggested by Roberts that, as the gouty paroxysm proceeds, the soluble quadriurate present in excess in the stagnant synovial fluid passes into the form of biurate, which is at first amorphous, and is finally deposited by the synovia in the crystalline form.

The urate is deposited in the superficial layers of the cartilage, but not on the surface, in the form of stellate crystals or needles (see Fig. 89). It is by their mechanical influence that they produce the local symptoms. The urates are deposited not only in the cartilages, but sometimes also in the synovial membranes and other parts of the body. Thus, the rim of the ear is a frequent seat of deposition, and the tendons, the skin of the hands, feet, and face, the dura mater, the pia mater, the sclerotic coat of the eye, the fibrous sheaths of the nerve trunks, and the kidneys, both the cortical and pyramidal portions, are also frequently the seat of deposit. The articular cartilages are exceedingly sensitive to interference in their texture, and the deposition in them gives rise to severe pain, but in other situations local symptoms may not exist.

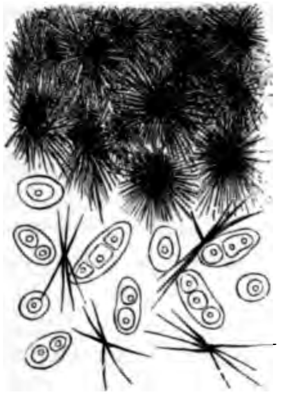

Fig. 89.—Cartilage of joint in gout, with crystals of urate of sodium. The salt is in stellate crystals which are nearly continuous at upper part of figure, which corresponds to surface of joint. × 200. (Cornil and Ranvier.)

The question of the general effect of an excess of urates on the body is an important one, but it is one not yet decided. It cannot be said that urates are poisonous in the ordinary sense of the term, but their presence in the blood seems to be accompanied by certain symptoms, nervous, digestive, etc., which may in part be due to it. The articular symptoms are undoubtedly the result of mechanical irritation.

Literature.—Garrod, Nature and Treatment of Gout, 1859; and Reynold's Syst. of Med., i., 1866; Gairdner, On Gout, 1849; Ebstein, Nat. u. Behandl. d. Gicht, 1882; and Lehre v. d. harns. Diath., 1891; Pfeiffer, Das Wesen d. Gicht, 1891; Roberts in Allbutt's Syst. of Med., iii., 1897; Luff (literature), Pathology and Treatment of Gout, 1898; Chalmers Watson (literature), Article in Encyclop. Medica, iv., 1900.

3. **Diabetes mellitus.**—This term is applied to a disease characterized by an excessive excretion of grape sugar or glucose by the urine. The condition of the urine is expressed by the term **Glycosuria.** In diabetes there is a prolonged and severe glycosuria. As the sugar passes into the urine from the blood, there must first be an excess in the latter, so that **Glycosæmia** is presupposed. The normal blood and urine contain a small amount of sugar; in diabetes it is excreted in enormous amounts, as much as 25 ounces in the day.

Since Bernard's discovery that **injury to a particular part of the nervous system** produces glycosuria, many methods of inducing that condition have been devised. The various methods of inducing glycosuria may be placed in four categories, namely, (i) injury to the nervous system, (ii) alteration in the vascular arrangements, (iii) extirpation of the pancreas, and (iv) the introduction of phloridzin. Perhaps the first two of these may be united under one head, as Bernard's diabetic puncture of the floor of the fourth ventricle probably acts by altering the vascular arrangements. The introduction of large quantities of a watery solution of common salt, and the inhalation of nitrite of amyl, an agent which causes relaxation of the arterioles throughout the body, is regarded by some as capable of inducing hyperæmia or other vascular change in the liver and chylopoietic system.

Excision of the pancreas, if incomplete, produces a temporary glycosuria, but, if the removal be complete, a permanent diabetes, so that the results of the latter experiment approximate closely to the disease proper. The excision of the organ must be complete, as it is found that if it be removed and a portion transplanted to the abdominal wall diabetes does not occur till the transplanted portion is also removed. This would indicate that it is not any nervous disturbance by the operation, but the removal of the secretion of the gland which is the cause of the glycosuria. It is not the recognized secretion, the pancreatic juice, whose absence produces diabetes, as the duct may

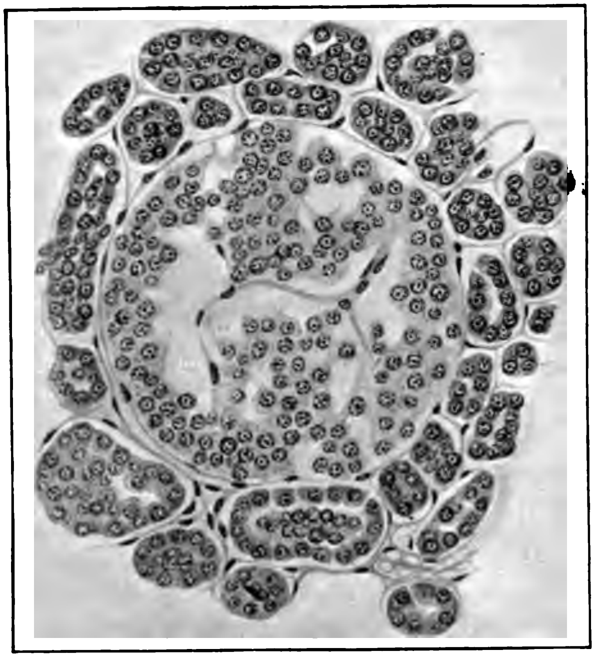

Fig. 90.—An interalveolar cell-islet in the midst of glandular pancreatic tissue. × 300.

be obstructed without any such effect, but it is presumably the suppression of an unknown "internal" secretion which is to be brought into account. It may here be mentioned that, in structure, the pancreas is a double organ, as, in the midst of the proper tissue analogous to that of the salivary gland, there are islands of a different structure, the so-called interalveolar islets (see Fig. 90).

Phloridzin-diabetes is the name given to the condition of glycosuria produced by the administration of phloridzin, a glucoside obtained from the root-bark of apple and pear trees. It is not a powerful poison, as it may be given in comparatively large doses, but when introduced into the stomach of a dog, to the amount of one part per thousand body-weight of the animal, it induces in a few hours a glycosuria which lasts for a day or two. The amount of glucose discharged is approximately one hundred times the weight of phloridzin introduced.

In considering these experiments in their bearing on the **pathogenesis of diabetes**, it is necessary to consider the relations of **glycogen** to sugar and the functions of these substances. It is generally accepted that the formation of glycogen by the conversion of carbo-hydrates and fats, and even of albuminous material, is an important function of the liver. Glycogen is believed to be the material necessary for the function of the working muscles, and it is found to have disappeared from the liver and muscles after severe labour. Now, in most of the experimental forms of glycosuria, the glycogen entirely disappears from the liver and from the muscles; it has been proved to do so pre-eminently in phloridzin-diabetes and in that produced by infusion of salt solution. There can be little doubt that the sugar abnormally produced has resulted from the conversion of glycogen, and in the experiments with salt solution the gradual conversion of the glycogen and the washing-out of the sugar was actually traced. It is therefore a probable explanation both of glycosuria as the result of experiment and of diabetes as a disease, that, for some reason, the glycogen of the body is induced to pass into the form of a glucose—a transformation which readily occurs.

It has next to be considered how these various methods of experimentation should induce this conversion of glycogen into sugar. In normal circumstances it may be supposed that the "internal secretion" of the pancreas, passing directly to the liver, hinders the conversion of its glycogen into glucose. The absence of this "ferment" after excision of the pancreas allows of the said conversion. In the case of phloridzin we have a substance allied to glycogen and glucose, and it has probably an influence in bringing about the transformation. Circulatory disturbances, by altering the rapidity of the flow and even the constitution of the blood in the liver may, in the other forms of experiment, also induce the transformation.

If such a transformation occur, then the glucose inevitably passes into the blood and on into the urine. The liver and muscles are liable to store glycogen because it is a colloid and non-diffusible, but when converted into sugar it becomes a crystalloid, and diffuses into the blood and so onwards.

An important point here is whether, in actual diabetes, there is, as in the experimental forms, with the exception of pancreas-excision, merely a conversion of glycogen and its discharge as glucose, or whether there is an **over-production** of these substances. It seems obvious that there is a great over-production. In actual cases of diabetes the appetite is greatly increased, and in spite of an excessive ingestion of food the tissues of the body are wasted. Food and tissues are utilized to produce ultimately sugar, which is discharged in great excess. The explanation of this is not far to seek if we premise that, in diabetes, there is an abnormal conversion of glycogen into sugar. Glycogen is the necessary material for muscular contraction, and is stored in the liver and in the muscles for the purpose. But if the store is continually being pilfered, then a physiological want of glycogen is produced. The liver is stimulated to excessive production of glycogen, but this ends in an excessive formation of sugar.

In regard to **the actual disease** and its causation it is undoubted that there are cases in which disease of the pancreas, in the form of atrophy, concretions, tumours, and inflammations, is present. But there are many cases in which no alteration is visible, and the only feasible explanation is vascular disturbance of nervous origin, or a direct effect by the nervous system on the function of the liver. Cases are recorded of lesions of the nervous system, such as injuries, tumours, softenings of the brain, as well as certain mental diseases being found in association with diabetes, but there are many cases in which no lesion possessing a causative relationship is discoverable.

In regard to the other changes in diabetes mellitus, little has to be said. The tissues appear to be peculiarly vulnerable; wounds heal badly, inflammations are generally very severe, often going on to suppuration and gangrene, phthisis pulmonalis often closes the scene, and is frequently very acute. General emaciation is a striking feature in advanced cases. The kidneys may be found enlarged and their epithelium fatty, but this has no direct connection with the essential pathology of the affection. Lipæmia sometimes occurs, but only in a small percentage of cases.

Literature.—Claude Bernard, many separate articles and a general work, Leçons sur le Diabète, 1877; Schiff, Zuckerbildung in d. Leber, etc., 1859; Seegen, Der Diabetes mellitus, 1875; Senator in Ziemssen's Encyclopædia; Frerichs, Ueber den Diabetes, 1884; Pavy, Researches on sugar formation, 1860; On diabetes, 1862 and 1869; Croonian lectures, 1878; Physiology of the carbohydrates, 1894; Dickinson, On Diabetes, 1875; Discussion on diabetes, Path. Soc. trans., vol. xxxiv., 1883; Cohnheim, Allg. Path., 2nd ed., 1882, vol. ii., p. 92; Traube, Virch. Arch., vol. iv.; Donkin, The relation between diabetes and food, 1875; Bock and Hoffmann, Reichert and Du Bois-Reymond's Archiv, 1871, and Ueber Diabetes, 1874; Hoffmann, Reichert and Du Bois-Reymond's Archiv, 1872, p. 746; Cohnheim und Litten, Virch. Arch., vol. lxvii.; Recklinghausen, Virch. Arch., vol. xxx.; Klebs, Handbuch der path. Anat., vol. i., p. 538; Lapierre, Sur le Diabète maigre dans ses rapports avec les altérations du pancreas, 1879; Duffey, Dubl. Jour. of Med., 1884; Hale White, Path. Soc. trans., vol. xxxvi., 1885; Mering and Minkowski (Extirpation of Pancreas), Arch. f. exper. Pathol., vol. xxvi., 1890; Lepine, Arch. de méd. expér., iii., 1891; Hedon, *ibid.*; Mering (Phloridzin), Verhand. d. Cong. f. inner. Med., 1888; Zeitschr. f. klin. Med., 1888 and 1889; Saundby (with copious references), Allbutt's Syst. of Med., iii., 1897; Williamson, Diabetes mellitus and its treatment, 1898, and in Encyclop. med., ii., 1899.

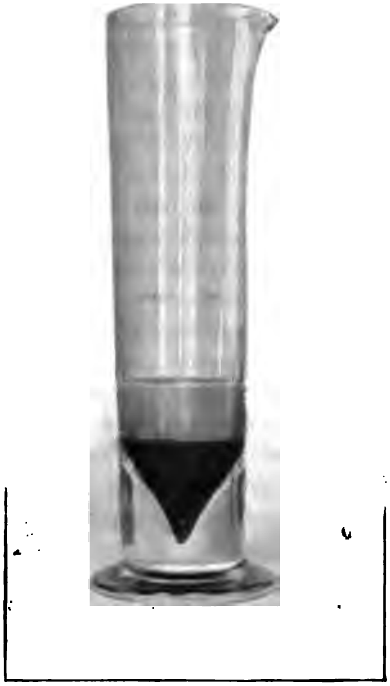

Fig. 91.—Lipæmic blood from the left ventricle of the heart.

4. **Lipæmia. Piarrhæmia.**—These names designate a condition in which fat is abnormally present in the blood.

There is a certain quantity of free fat in the blood normally, and after a meal it may be somewhat abundant. In lipæmia, however, there is so much fat present as to give the blood a peculiar milky appearance to the naked eye. When the blood is collected in a vessel the fat rapidly separates and rises to the surface like cream (see Fig. 91). Under the microscope the fat is visible as fine fat drops (see Fig. 92), which are free or else enclosed in cells. The fat may be present (in some cases of diabetes) in such quantity as to alter the entire appearance of the blood. Thus the blood in the vessels will present opaque white portions where the fat has come to the surface. The fat is generally finely divided, but it may be caught in the fine arteries and capillaries of the lungs, the brain, the kidney (Fig. 93), and the liver. It is readily detected in the glomeruli of the kidney, and it may pass thence into the urine, constituting a form of chyluria.

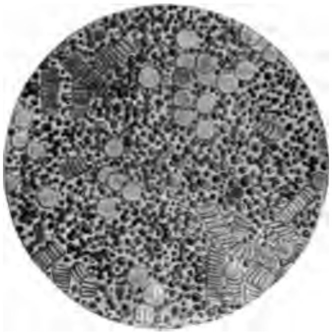

Fig. 92.—Blood in lipæmia. The larger circles and discs are red blood-corpuscles; the smaller bodies are fat drops. × about 600.

Lipæmia has been met with in its most aggravated form in diabetes, but it also occurs as a consequence of alcoholism, in some cases of dyspnœa, and in relapsing fever. The source of the fat is obscure. By some it is believed that it is the fat of the food which is not oxidized and so accumulates, but this is not a probable explanation. A more probable one is that it arises by fatty degeneration of the endothelium of the blood-vessels in the spleen and elsewhere, and perhaps it does so in some forms of lipæmia. But the enormous amount of fat found in some cases of diabetes precludes the idea that it can be derived from a fatty degeneration of the endothelium. In some such cases, almost the entire blood has a milky appearance. The only probable explanation of this seems to be that the sugar which is present in the blood in diabetes in large quantities has been replaced by or converted into fat.

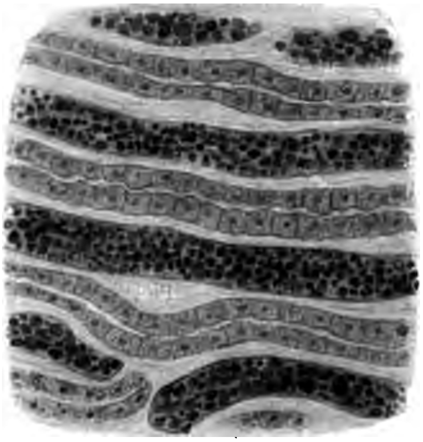

Fig. 93.—Kidney in lipæmia, from a preparation stained with osmic acid. The dark spots are fat drops contained in the capillary vessels. × about 200.

Ponfick found, in cases of relapsing fever, cells in a complete state of fatty degeneration in the blood, especially in that of the splenic and portal veins.

These cells were endothelial cells of blood-vessels, which in consequence of becoming fatty were readily separated and carried off by the blood. The author observed in a case of diabetes with extreme lipæmia a very striking fatty degeneration of the endothelium of the splenic pulp, so that the organ as a whole presented an opaque pinkish appearance suggestive of salmon roe. The fatty degeneration was observed in the endothelium of the capillaries of the liver and elsewhere, but not to such an extent as in the spleen. In another case these conditions were present but less marked. In these cases, however, there was no appearance in the blood of free cells presenting fatty degeneration. Looking to the fact that in the kidneys, spleen, brain, liver, lungs, and elsewhere, the blood was occupied by very finely divided fat, the only probable conclusion seems to be that some constituent of the liquor sanguinis had become converted into fat, and that in this conversion the sugar present in the blood has played some important part.

Hamilton and Sanders suggested that the coma which frequently marks the fatal termination of diabetes may be due to the accumulation of fat in the blood. One cannot but believe that the lesion must have an important effect on the function of the blood, but there is sufficient evidence to show that diabetic coma often occurs independently of lipæmia.

Literature.—SANDERS and HAMILTON, Edin. Med. Journ., July, 1879; CHRISTISON, Edin. Med. and Surg. Journ., vol. xxxii., 1830; HUSS, Der chron. Alkoholismus, 1852; LANCEREAUX, Traité d'anat. path., vol. ii.; PONFICK, Virch. Arch., vol. lx., pp. 166, 169; COOTE, Lancet, Sept., 1860. See also under Diabetes.

5. **Melanæmia.**—By this name is meant, literally, black blood. It is used to designate a condition in which pigment occurs abnormally in the blood and is deposited in the tissues. The pigment is in the form of solid granules, and, although black in colour, it is derived from the blood pigment, and contains iron. It is met with in cases of malarial fever, but not in every case; as a rule only in the more severe forms. The origin of this pigment has been determined by Laveran to be the colouring matter of the blood altered and set free by the parasite, which is the cause of malarial fevers.

When the pigment gets into the blood it is rapidly taken up by the white blood-corpuscles, so that these appear in the blood as pigmented cells. These pigmented cells are often larger than normal white corpuscles, being enlarged by their abnormal contents. It will thus be seen that very little free pigment will be present in the blood except immediately after the acute paroxysm, the white corpuscles picking up the solid granules just as they do when a solid pigment, such as vermilion, is artificially introduced into the blood of an animal (see Fig. 94). The white corpuscles containing the pigment accumulate in certain organs, especially the spleen, liver, and bone-marrow. In the spleen and bone-marrow the pigmented cells appear to leave the capillaries readily, and pass into the tissues, producing an actual pigmentation of them, but in the liver they linger longer in the capillaries, which may be seen with many such corpuscles in them, although here also the latter may pass out into the surrounding tissue. In very severe cases, other organs and tissues may be pigmented in this way. The brain is very often pigmented, especially in cases where there has been much cerebral excitement. The kidneys are sometimes the seat of it as well as other tissues, such as the pancreas, intestine, etc.

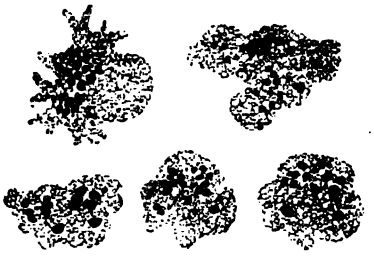

Fig. 94.—White blood-corpuscles of the frog, containing granules of vermilion, and showing amœboid movement. (After KLEIN.)

This abnormal pigmentation of course produces changes in the colour of the organs affected. The spleen is slaty-grey or almost black, the liver is steel-grey or blackish, the grey substance of the brain is of a dark chocolate or graphite colour, and the kidneys present greyish spots.

Literature.—ARNSTEIN, Virch. Arch., vol. lxi., p. 494; MOSLER, Virch. Arch., vol. lxix., p. 369; LAVERAN, Paludism, New Syd. Soc. trans., 1893. See also literature of Malaria.

6. **Myxœdema.**—This condition was first described by Sir William Gull under the designation Cretinoid state. Dr. Ord recorded further cases, and suggested the term Myxœdema. It is a condition due to diminution of the secretion of the thyroid body, this being an internal secretion, as the thyroid is a ductless gland. The absence of the thyroid secretion alters the metabolism of the tissues, the principal result being an excessive production of mucin, with marked degradation of the functions of the nervous system. The relation of these symptoms to the defect of the thyroid is demonstrated by the striking improvement following the administration of extract of the thyroid glands of animals. The potency of the secretion is also shown by the fact that an overdose of the extract leads to pronounced symptoms in which mental excitement and excitement of the heart are prominent.

The disease manifests itself first as a swelling of the skin and subcutaneous tissue generally, which resembles ordinary œdema, but differs in respect that it is not influenced by gravitation, and does not pit on pressure. The affected parts have a peculiar translucent appearance. Besides the change in the skin there are pronounced symptoms pointing to the nervous system, chiefly weakening of the intellectual powers, dulness of sensibility, muscular weakness, etc.

The condition of the skin is due mainly to the fact that mucin is present in excess, but there are also signs of irritation in the form of accumulation of round cells. The hairs are liable to atrophy and t secretion of the sweat and sebaceous glands is diminished.

The chemical examination of the skin and subcutaneous tissue by Dr. (showed a great excess of mucin. His examination was in a case in an early st with the full swelling of myxœdema still present. Chemical analysis of cases a later stage shows that in them the mucin is scarcely in excess, and the swellin the skin is due largely to an increase of subcutaneous fat. In the experime in animals by Horsley, in which examinations were made in an early stage, th was found an excess of mucin not only in the skin, but also in the fibrous tiss blood, and salivary glands. The parotid gland, which normally contains no mu presented that substance in large quantity. It showed on microscopic examina the usual appearances of a mucous gland secreting mucus, namely, gland cell the acini distended with mucin and having the characteristic appearance of go cells.

There are less constant changes of a similar nature elsewhere, a the mucous membrane of the mouth, and the teeth are liable to d out like the hairs from the skin. There are also in some cases in stitial changes in the sympathetic nerves, kidneys, liver, heart, submaxillary glands (Virchow).

Myxœdema has been found uniformly associated with **Atrop disease of the thyroid gland.** The gland is usually diminished in s and has a yellowish or pale appearance instead of the usual dull colour. The condition seems to depend on an interstitial inflam tion of the gland. There is an infiltration of round cells betw the vesicles, followed at first by proliferation of the epithelium in vesicles, but succeeded by atrophy. In a more advanced period gland tissue is replaced by fibrous tissue in which the remains of proper gland tissue are represented by clumps of round cells. Th is practically a cirrhosis of the gland (see Fig. 95).

The connection between myxœdema and destruction of the thyr gland has been shown in various ways. Excision of the gland disease in man gives rise to a condition virtually identical w myxœdema in a considerable proportion of cases. Kocher descri the results of thyroidectomy without being aware of the previ descriptions of myxœdema, and the two descriptions are very simi obviously referring to the same conditions. The myxœdema follow excision of the thyroid has been described under the name of **Cache strumipriva** or **thyreopriva.**

Extirpation of the thyroid gland in animals is followed, especi in the case of monkeys, by conditions closely resembling those myxœdema, sometimes in an acute, sometimes in a chronic form.

The **pituitary body** (or hypophysis cerebri) has a structure res bling that of the thyroid gland, and its function is probably simi

In some cases of myxœdema enlargement of the pituitary body has been observed, so that it fills out and causes enlargement of the sella turcica.

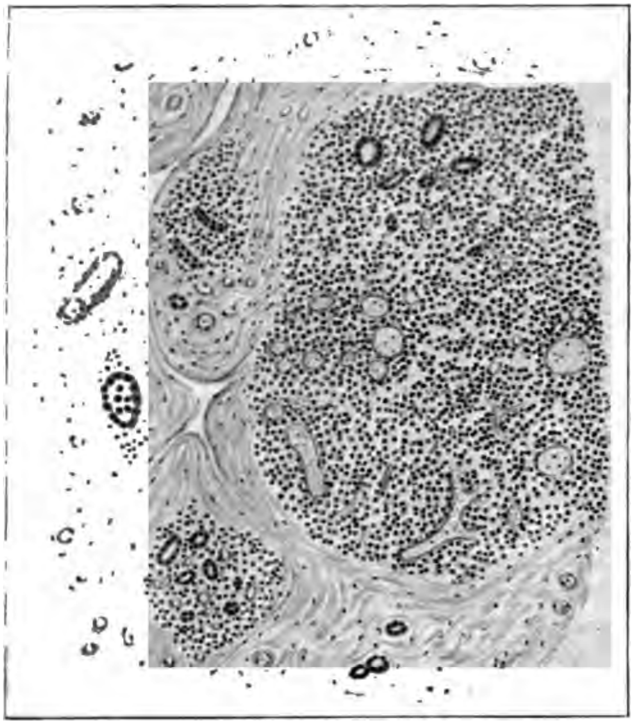

Fig. 95.—Thyroid gland in myxœdema. Round-celled tissue invading the glandular tissue is shown. Most of the glandular vesicles have disappeared. New-formed fibrous tissue is seen at the margins. × 100.

7. **Cretinism.**—This name is applied to a condition in which the body is stunted from deficient growth of the long bones, the nose is sunk from imperfect growth of the base of the skull, the head is proportionally large and the neck short, and the intellect is very defective. It is mostly endemic, but sporadic cases occur. The thyroid gland is affected in almost all cases of cretinism, and the condition has been ascribed to disease of the gland either of congenital origin or occurring in early life. The condition of the thyroid gland is not always the same. There may be a regular goitre, and it is interesting that goitre and cretinism are sometimes endemic in the same localities. In other cases the thyroid gland is cystic, and in others it is atrophic. In a case recently examined by the writer, every trace of thyroid gland tissue

had disappeared. It is to be remarked that an apparent enlargement of the thyroid gland may be associated with atrophy of its proper secreting tissue, and that goitre is often associated with defect in the function of the gland.

There are several grounds for regarding cretinism as due to disease producing defect in the secretion of the thyroid. One of these is that the phenomena closely resemble those of myxœdema or cachexia strumipriva, especially when these have been observed in the young subject. The fact that Gull applied to myxœdema the name of cretinoid state is evidence of the close resemblance between the two conditions. Again, it has been found that in some cases where children presenting the general symptoms of cretinism have been treated with thyroid gland they have shown much improvement. It is expected by many that the endemic cretinism of some localities may be in part overcome by this treatment, but sufficient time has not elapsed to bring the matter fully to the test.

If this view of the nature of cretinism be correct, then it may be asserted that the loss of the thyroid secretion, when it occurs at an early age, causes defective growth of the bones and such a dulling of intellect as to constitute idiocy.

Literature.—Gull, Trans. of Clin. Soc. of London, 1873; Ord, Med. chir. trans., 1877, also in Allbutt's Syst. of Med., iv., 1897 (with literature), and Lancet, 1898; Reverdin, Rev. méd. de la Suisse Rom., 1883 and 1887; Kocher, Arch. f. Chirurgie, xix., 1883; Virchow, Berl. klin. Wochenschr., 1887; Horsley, Festschr. f. Virchow, 1891; De Quervain, Virch. Arch., cxxxiii., 1893; Boyce and Beadles (Hypert. of pituitary), Jour. of path., i., 223, 1893. A very full account of Myxœdema, with history and literature in Report to Clin. Soc. of London, 1888. In this, papers by Ord, Halliburton, Horsley, Semon, etc.; Halliburton (mucin in myxœdema), Journ. of Path. and Bact., i., 90, 1893; Ewald, Die Erkrank. d. Schildrüse, 1896; Murray in Encyclop. Medica, xii., 1902.

8. **Exophthalmic Goitre** (*Graves' Disease, Basedow's Disease*).—In this disease the condition of the thyroid gland is only a part of the morbid phenomena. The eye-balls are prominent, the heart is liable to excited action, and there are frequently tremors of the extremities. These are often associated with a perverted mental state, with emaciation, anæmia, loss of strength, etc.

The thyroid gland is enlarged, usually moderately and symmetrically. The enlargement is uniform, but sometimes nodular elevations project from the surface (see Fig. 96). It is more vascular than normally, enlarged and tortuous vessels coursing over its surface. The tissue has a brownish colour, and its consistence, though firm, is generally less firm than that of the healthy gland. The striking feature microscopically is the increase of glandular tissue. The epithelium tends to elongate and ssume a columnar form, and often a papillary arrangement. Desquamation is not uncommon. The secretion within the spaces is usually

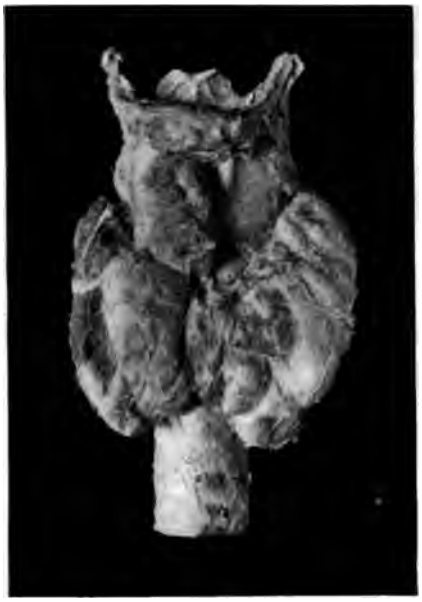

Fig. 96.—Thyroid gland in exophthalmic goitre. There is moderate enlargement of the gland. A distinct pyramidal process is present.

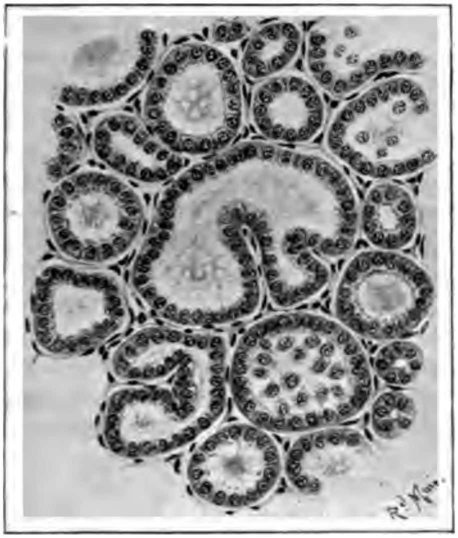

Fig. 97.—Thyroid gland in exophthalmic goitre. The prominent epithelium desquamating at parts and the scanty secretion within the spaces are shown. Papillary ingrowths are indicated. × 200.

scanty, and more or less fluid (see Fig. 97). New-formed tubu spaces lined with cubical epithelium are also found. The appeara of the altered gland has been likened by Greenfield to a saliv gland. Shrinking from the development of fibrous tissue may oc late in the disease. The thymus gland frequently persists. Alterati in the central nervous system and in the sympathetic have b described. They are not constant. The most probable explanatio that the disease is due to some alteration in the thyroid gland appara The function of the gland is altered, and we may infer the characte the secretion is altered. The connection between the thyroid gl and the parathyroids has been emphasized of late years, and it se more than probable that disturbance of the function of the parathyr may play an important, if not indeed a primary, part in the pathog of the disease.

Literature.—GRAVES, Clin. Lectures, 1835; BASEDOW, Wochenschr. f. d. Heilk., 13, 14, 1840; GREENFIELD, Brit. Med. Journ., ii., 1893; EDMUNDS, Jo of Path. and Bact., iii., 1896; ORD and MACKENZIE (with full literature), Allb Syst. of Med., iv., 1897; GLEY (with references), Brit. Med. Journ., ii., 1901.

9. **Acromegaly.**—This condition is in all probability to be inclu amongst the diseases due to alteration of secretion and excretion. gland concerned is the Pituitary body, which in the majority of *mortem* examinations has been found greatly altered. It is usu hypertrophied, the increase in size being due to glandular hyperpla or to the presence of a growth, most commonly sarcomatous in nat

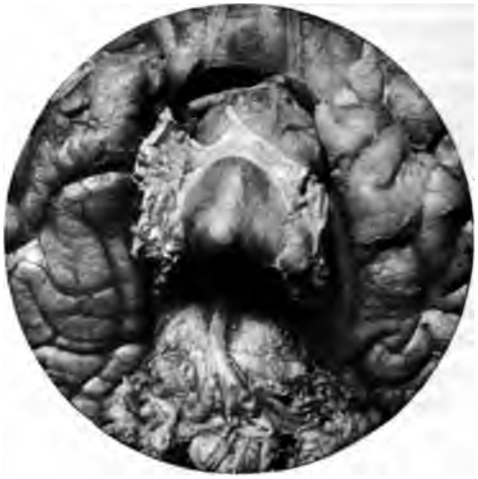

Fig. 98.—Sarcoma of Pituitary body.

(see Fig. 98). There may be atrophy of the gland and cystic transformation. The enlargement is sometimes so great as to cause enlargement and deformity of the sella turcica.

The term Acromegaly means enlargement of the extremities, and it is used to designate a condition whose recognition is chiefly due to Marie and Souza Leite. The disease is very gradual in its onset, and essentially chronic in its course, often lasting for 15 or 20 years. Both men and women are attacked, usually between the ages of 20 and 40. The main characteristics of the affection are progressive enlargement of the face, marked enlargement of the hands and feet, muscular weakness, and severe headache. Blindness and other symptoms resulting from pressure are common (see Figs. 99 and 100).

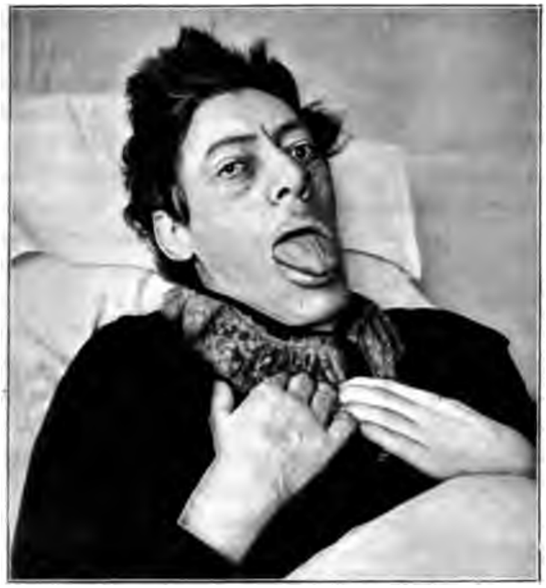

Fig. 99.—Acromegaly in a woman. The enlargement of the face and hands, the hypertrophy of the tongue, and the coarse wiry character of the hair are shown. There was complete loss of vision in the right eye.

Owing to the changes in the face the diameter of the head is increased antero-posteriorly. The lower jaw is specially affected, and frequently projects beyond the upper teeth. The nose as a whole may be greatly increased in size. The lips are thickened, and the lower lip tends to protrude or fall down. The tongue is broad and soft, and seems too large for the mouth (see Fig. 99).

The anatomical lesions are principally of the bones. There is an enlargement of their outline by a new-formation of cancellous bone.

Thus the bones of the hand are increased in breadth, and are roug the surface, but there is no proportionate increase in length. In a described by Middleton, the elbow, wrist, and knee-joints were affe but this is exceptional. The integuments are enlarged over hypertrophied bones, and very great deformity ultimately res the hands being like great unwieldy fins. (See Fig. 100.) enlarged fingers are more or less uniformly increased in size, somet sausage-shaped. The nails are flat, ridged, or striated, and (brittle. The feet show corresponding deformity. **Hypertrophic monary Osteo-arthropathy** is a peculiar affection which has confounded with Acromegaly. It is treated under Diseases of Bor

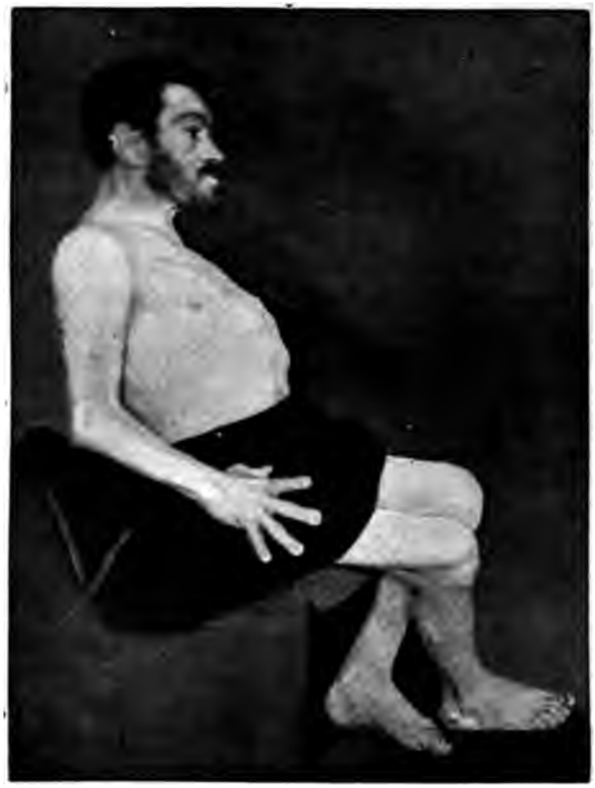

Fig. 100.—Acromegaly in a man aged forty-nine. (MIDDLETON.)

Literature.—MARIE and SOUZA LEITE, New Syd. Soc. trans., 1891; RECK HAUSEN, Virch. Arch., cxix.; DUCHESNEAU, L'acromégalie, 1892; COLLINS, Jou Nerv. and Mental Disease, Dec., 1892, and Jan., 1893; MIDDLETON, Clin. Rec 1894; SCHMIDT (with literature), Lubarsch and Ostertag, Ergebnisse, 1900.

10. **Addison's Disease.**—The pathology of this disease is still very obscure, but the connection of myxœdema with disease of the thyroid has suggested that the symptoms may be due to defect in the secretion of the supra-renal bodies, which in the vast majority of cases are found

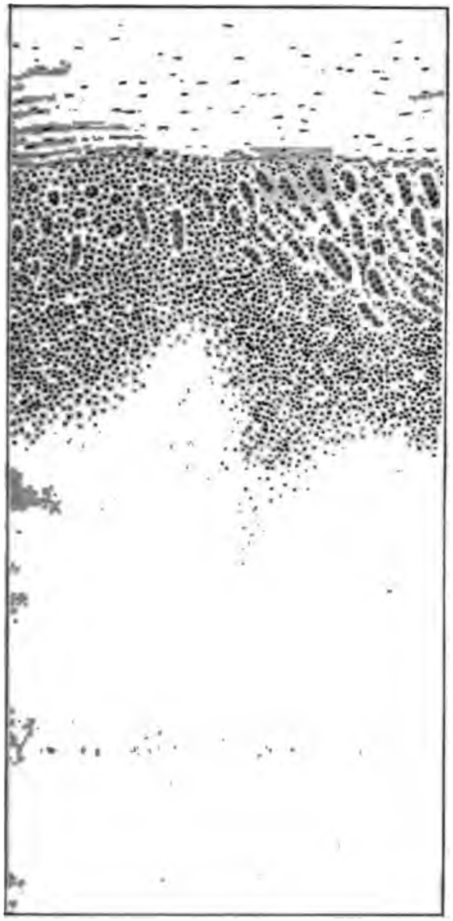

Fig. 191.—Caseous tuberculosis of the suprarenal gland in Addison's disease. The lower half of the illustration shows a caseous mass. The cellular infiltration at the periphery is seen invading the glandular tissue. In the upper part there is fibrous thickening of the surface of the gland. × 100.

diseased. Extract of the supra-renal bodies produces in animals increased tension in the vascular system, muscular weakness, and rtain nervous phenomena, so that the gland produces an energetic gent, whose absence may be presumed to lead to distinct symptoms. On the other hand, the fact that the *supra-renal* bodies are so intimately related to the semilunar ganglion and neighbouring plexus, and the possibility that they themselves may be largely nervous organs, renders the disentanglement of Addison's disease peculiarly difficult.

The disease is characterized by a peculiar **bronze pigmentation** of the skin and pigmentation of the buccal mucous membrane, and, what is more important, by constitutional symptoms, such as loss of appetite, inclination to vomit, and general debility, usually ending fatally in about two years. The disease in the supra-renal bodies is usually tuberculosis, which attacks both organs, and causes great destruction of their substance, sometimes amounting to its absolute annihilation (see Fig. 101). On the other hand, there is usually, if not constantly, a matting and contraction around the diseased organs which seriously affects the nervous structures in this neighbourhood.

Literature.—ADDISON, Dis. of supra-renal capsules, 1855; OLIVER and SCHÄFER, Journ. of Physiol., 1895; OLIVER, Brit. Med. Jour., 1895; ALEXANDER, Ziegler's Beitr., xi., 1891; VON KAHLDEN (pigmentation), Centralb. f. allgem. Path., vii., 1897; ROLLESTON in Allbutt's Syst. of med., iv., 1897, and Encycl. medica, i., 1899.

SECTION VII.

PYREXIA—FEVER.

Normal temperature, resulting from balance of production and discharge of heat, regulated by a calorific centre in the brain. Limitations of power of regulation when body exposed to excessive cold or excessive heat. **Causation and Forms of Pyrexia**—Production from lesions of nervous system. Post-mortem rise of temperature. Pyrexia from contamination of the blood, Fever proper; usually due to action of microbes; phenomena of cold stage, of fastigium, and of crisis. **Theories of Pyrexia**—The nervous and the metabolic theories. Arguments in favour of the latter. **Other Phenomena of fever**: cloudy swelling, increased rate of pulse and respirations, fall of blood-pressure and nervous disturbances. **Post-mortem appearances in fevers.**

UNDER the designations pyrexia and fever are included conditions of the body in which the constant phenomenon is an elevation of the temperature of the body. In order to understand this pathological change we must first consider the normal temperature and the causes to which it is due.

Normal temperature.—It is a remarkable fact that in man, as in other warm-blooded animals, the temperature of the body is maintained at all climates at a nearly constant level, there being in the healthy person merely slight daily variations. The normal temperature may be stated at about 99° Fahrenheit or 37° Centigrade. The fact implies that the loss of heat by the body balances the production of heat in the body. The production of heat is by a process of combustion, and its amount will vary with the quantity of oxygen absorbed and carbonic acid given off, just as in any ordinary combustion.

Normal heat production.—This combustion occurs in the living tissues, and therefore they are the seat of heat production. The chief sources of heat are the active muscles, the secreting glands, and the nervous system, but all the active tissues of the body contribute.

Many facts render it apparent that heat is produced in much greater quantity in **muscular contraction** than in the performance of any other function. We are not only sensible of a great production of heat during muscular exertion, but actual measurement has shown that during contraction the muscles produce an increased amount of heat.

During severe muscular exertion the body temperature, as measured in the axilla or mouth, has been found elevated as much as from 0·5° to 1° Centigrade. Also, the amount of heat given off while prisoners were exercising on the treadmill has been found to be very excessive. Again, the measurement of the temperature of contracting muscles has shown that heat was being produced. The human biceps, even before contraction, has a temperature of about 1·5° to 2° C. above that of the surrounding connective tissue, this being due to the continual tonic contraction of the muscle; but during contraction the temperature rises 0·5° to 1° C. (Breschet and Becquerel, Macalister.) Bernard also found the blood of the muscular branch of the jugular vein increased in temperature during contraction of the muscles of the jaw. Then, also, there is the great rise of temperature occurring in tetanus, whether artificially produced in animals or occurring as a disease in man. In the former case, when tetanic spasm is produced by electric stimulation, the temperature of the body may rise 5° C. In man very high temperatures have been registered in tetanus. Wunderlich has found it as high as 44·75° C. (112·5° F.), and after death 45·4° C. (113·6° F.).

The muscular tissue of the body seems to be a constant source of heat production. The voluntary muscles are in a continuous state of tonic contraction, and the heart is constantly producing heat by its contractions. It has been calculated by Gréhart that the heat produced by the heart is about equal to a twenty-fourth of that of the whole body.

Next to the muscles the **Secreting glands** seem to contribute most to the heat of the body. Ludwig found that when the submaxillary gland is stimulated the secreted saliva is warmer than the blood of the carotid, and Bernard found the blood leaving the glands warmer than that passing to them. The intestinal glands and the liver are also great sources of heat. Bernard found the blood of the portal vein 0·1° to 0·4° C. higher than that of the aorta, and the blood of the hepatic vein 0·2° to 0·4° higher than that of the portal, showing that heat is produced first in the glands of the intestine and then in the liver. The highest temperature in the body is said to be found in the liver.

The central **Nervous system** is also a heat producer. Observation in animals which had been artificially cooled and hibernating marmots showed that electric stimulation of the nervous system causes rise in temperature in the brain.

The temperature of the body rises slightly after the ingestion of food. This may be due to the activity of the glands concerned in assimilation, or to the oxidation of the products of digestion in the blood.

The production of heat is approximately measured by the consumption of oxygen and elimination of carbonic acid. In the case of a cold or tepid bath, more heat must be produced in order to compensate for its extraction by the unusually cold medium. Experiment shows that under these circumstances there is an increase in the absorption of oxygen and exhalation of carbonic acid. In man the experiment cannot be long continued, and it cannot be said that the results give more than an approximate indication of quantities. The carbonic acid produced may, for example, be retained to some extent in the body and so the results *vitiated*.

Discharge of heat.—The living body is continually giving off heat in various ways, but chiefly by the skin and lungs. There is a constant radiation and evaporation from the surface of the body, while in the lungs there is a continual cooling of the respiratory surfaces by the inspired air, and a further loss of heat by the evaporation of moisture from these surfaces. The amount of heat lost will depend on the one hand on the extent of the cutaneous surface, its temperature, the activity of perspiration, and the temperature of the surrounding media, and on the other hand on the depth of the respirations and the temperature of the inspired air.

Regulation of temperature.—The fact that in healthy persons the temperature remains close to a constant normal, indicates that there are arrangements in the body whereby the production and discharge of heat are regulated in their amount. These arrangements are under the control of the nervous system, which must contain a **Calorific centre,** located by some observers in or above the pons, and more particularly in the corpus striatum, the puncture of which in animals produces a fever commencing in a few hours and lasting several days; by others, with less evidence, in the cortex of the cerebrum, about the middle of its lateral or external surface. The regulation of temperature takes place chiefly by modifying the discharge of heat on the one hand, and its production on the other. That is to say, the state of the skin as regards fulness of its vessels, and activity of the sweat-glands is subject to variation according as heat requires to be economized or expended. The respiratory movements are also subject to variation, according to need. Human beings, again, assist in the regulation by clothing themselves according to the requirements of the body. By these means the central nervous system, chiefly through the vaso-motor and respiratory nerves, regulates the loss of heat. The production of heat is also to some extent controlled by the nervous system. When more heat is needed the tonicity of the muscles is increased, they become harder and more braced. Shivering is a kind of exaggerated tonicity whose rationale seems generally an increased production of heat.

The limits of the power of regulation are seldom reached in healthy persons. Almost any variation in the amount of heat produced is compensated by alterations in the state of the skin and respiration. Not even the severe muscular exertion of climbing a mountain, producing, as it does an enormous excess of heat, is able to raise the temperature of the body appreciably. It is interesting to observe, however, that violent contraction of muscles produced by morbid influences will raise the temperature. It is so in convulsions such as those occurring in epilepsy, uræmia, or tetanus.

The power of regulation is not so great against variations in the external temperature. Prolonged exposure to cold, especially when the muscles are relaxed, frequently reduces the temperature. Some very low temperatures have been observed (Macewen, Reincke, Peter) in drunkards who have lain exposed. On the other hand a high temperature in the surrounding media will sometimes raise the body temperature. If the air be dry the body can meet a considerable elevation of temperature, compensation being effected by excessive perspiration, but if the air be moist as well as hot, or if a bath be used, then the temperature will rise.

As the actions of the body involve the production of heat, if the temperature of the surrounding media be even near, without quite reaching that of the body, then a prolonged exposure will raise the latter. When a rabbit is kept in a box at a temperature above 32° C., its temperature rises, so that when the air is at 36°, the temperature of the animal has risen to 41 or 42° (Rosenthal). In guinea-pigs Cohnheim observed a similar result. Again, Stapff found during the construction of the St. Gothard tunnel that men working in damp air at about 30° C. had their temperature raised to 40° C. (104° F.).

The regulation may be rendered inefficient by some interference with the regulating apparatus. Thus, persons in a state of starvation or anæmia are not in a condition to increase the production of heat so readily as others, and hence they are less able to withstand cold. Again, interference with the vaso-motor nerves may hinder the compensation effected through them. Thus, the division of the sympathetic nerves in the neck of rabbits, by paralysing the vaso-motor nerves of the ears, produced an active congestion in these parts, which lowered the temperature two degrees C. Animals paralyzed by curare or alcohol are more readily cooled than normal ones, both because the muscles are relaxed and because the cutaneous vessels are dilated. **Varnishing the bodies** of rabbits (with tar, linseed oil, collodion, etc.) causes a hyperæmia of the skin and thus produces a lowering of temperature which may be fatal. Similarly, extensive burns, by producing an active congestion of the skin, lead to a lowering of temperature. In both cases, if precautions are taken against cooling, the temperature is not reduced. Hence the treatment of burns by wrapping in cotton-wool.

Post-mortem rise of temperature is not infrequently observed, especially when the temperature has been above normal at the time of death. This is explained by the fact that the tissues do not all die simultaneously, and that there may be considerable heat production after the heart has ceased to contract. The cessation of the circulation in the skin will greatly reduce the loss of heat by radiation, and the internal heat production may temporarily counterbalance the loss. A similar explanation is given by Cohnheim of the rise of temperature in the **collapse stage of cholera**. Here coldness of the surface is associated with rise of internal temperature. The former is ascribed to defective circulation in the cutaneous vessels, due to the thickening of the blood which results from the loss of fluid by the bowels which is characteristic of cholera.

There is sometimes a rise of temperature **just before death** in diseases of the central nervous system, as first pointed out by Wunderlich. This is sometimes associated with convulsions or spasms, but may occur without these, and is difficult of explanation.

Causation and forms of pyrexia.—Among the conditions in which elevation of temperature occurs, there are two distinct classes of cases, which may indeed be used as mutually illustrative of the pathology of fever, but which in the first instance must be kept rigidly apart. There are, on the one hand, cases due to disease or injury of the central nervous system, and, on the other hand, cases in which a poison of some sort is present in the blood. It is to the latter class of cases that the term Fever is usually applied, this term including other symptoms besides mere elevation of the temperature.

Pyrexia from lesions of the central nervous system.—There are many cases on record in which injuries or diseases of the brain have led to elevation of temperature, sometimes to a high degree. These clinical observations have been confirmed by physiological experiment. The clinical cases consist of various lesions of the brain and cord, such as tumours, injuries, hæmorrhages, etc. The experiments were generally such as separate the medulla oblongata from the pons.

Dr. Hale White has made a very admirable collection of cases of pyrexia from disease of the nerve centres. He classifies the cases in twelve groups, which include tumours of the brain and cord, hæmorrhages, especially of the pons, embolism, ill-defined degenerations, insular sclerosis, locomotor ataxia, obscure nervous cases (including hysterical pyrexia), mental disease, injuries to the spine and brain. He endeavours to give unity to the cases on the ground that in all of them there is interruption of nerve-fibres passing from a supposed centre in the motor region of the cortex of the brain.

From these observations an endeavour has been made to establish the existence of a calorific or thermic centre in the brain, that is to say, of a centre which, by its own action, is capable of producing heat. We have seen that the nervous system has arrangements for the regulation of the temperature, but there is not sufficient evidence that there is any single centre having a direct control of the process of heat production. The lesions which lead to elevation of temperature are such as to produce complex derangement of the vaso-motor and muscular functions, and it cannot be said that these have been sufficiently eliminated to prove the existence of a centre which produces its effects apart from the ordinary processes in the muscles, blood-vessels, etc.

According to the views of Wood, which are partly adopted by Hale White, the heat-producing tissues have a continual tendency to produce too much heat, and the thermal centre is chiefly exercised in controlling or inhibiting the process. As the nervous lesions which cause a rise in temperature are chiefly such as paralyze or divide the nervous connections, it is supposed that they act by removing the inhibition of the thermic centre.

Pyrexia from contamination of the blood. Fever proper.—In the great majority of cases pyrexia is produced by the existence in the blood of abnormal matters. These, as we have seen, are most commonly the products of the action of microbes, but the microbes themselves need not enter the blood; it is sufficient that their toxins be present there. Thus putrid matter injected into the blood gives rise to fever, but it does so when all solid particles have been removed, and only the dissolved products used. In the case of putrid wounds or inflammations, we commonly have fever, but there is not usually any actual propagation of bacteria in the blood. In tuberculosis also, fever is usually present, but it seems doubtful whether the tubercle bacillus is at all capable of multiplication in the blood.

But fever may be produced without the agency of microbes. It has been induced by the injection of small quantities of water containing granules of starch or charcoal. These particles having caused obstruction of the pulmonary capillaries, the blood shut off from the circulation undergoes metamorphosis, and its products, being absorbed, cause pyrexia. The products of metamorphosis of the blood, produced in other ways, may lead to fever. Thus the injection of large quantities of pure water, apparently by causing solution of the red corpuscles, leads to elevation of temperature (Billroth and others). Even an extravasation of blood in the tissues and the absorption of its products may lead to pyrexia. Thus Volkmann found that in 14 cases of simple fracture of the femur, fever was present in 11 cases, in 5 it lasted for several days, in one as long as ten.

Fevers have been divided into three stages, namely, rigor or cold stage, fastigium or acme, and crisis.

During the **Cold stage** there is a marked feeling of cold, and the skin is cold to the touch, and pale or livid in appearance. The feeling of cold is actually due to a reduction in the temperature of the skin, and the shivering which is often pronounced in this is a reflex stage phenomenon, just like ordinary shivering from cold. The coldness of the surface is due to a general spasm of the cutaneous arteries.

While the surface is cold there is a great rise in the internal temperature. This rise may be partly the result of the diminished loss of heat from the surface, but is not entirely so. The rise is too great to be accounted for in this way. For instance, Liebermeister found that in the cold stage of intermittent fever the temperature in the rectum rose in thirty minutes as much as 2·31° C. (4° F.). This author also determined that in the cold stage there is a great increase in the process of combustion, as evidenced by the elimination of carbonic acid. The very rapid rise in temperature is therefore due to increased production, with diminished discharge of heat.

The Fastigium is characterized by a more or less continued elevation of temperature, which may last for days and weeks and keep near that attained at the end of the cold stage. There is a great increase both in the production and discharge of heat. The former is evidenced by an increased absorption of oxygen and discharge of carbonic acid, and the latter has been determined by actual observation. The hot skin of the fever patient is generally a sufficient indication of excessive discharge of heat, but Leyden has demonstrated it by experiment, in which the leg was put into a bath, and the loss of heat measured by the rise in temperature in the water.

As the fever patient eats less than a healthy person, the excessive production of heat takes place, to a large extent, by the combustion of the tissues. Hence, as the fever progresses, there is great **Wasting of the tissues**, both of the adipose tissue and the proper nitrogenous tissues. The consumption of the nitrogenous tissues is expressed by the appearance in the urine of an **excess of urea**, which is the chief ultimate product of the metabolism of the nitrogenous principles in the body.

Under ordinary circumstances the **amount of urea** and other nitrogenous substances in the urine bears a close relation to the diet, being greatly diminished during fasting; hence the excretion of urea in fever can only be appreciated by comparing it with that of a healthy person on the same diet. A young healthy man on ordinary febrile diet will excrete 16 to 18 grammes (245 to 275 grains) of urea, while a similar person in fever will excrete 40 to 45 and even 50 grammes. The excess of urea has been stated by Unruh at 50 per cent., by Liebermeister at 70, and by Senator at 100.

It is a point of great interest that the increase of urea begins in some cases before the rise of temperature (Sidney Ringer and others). This has been observed chiefly in relapsing fever, and indicates a period in which the fever is latent. There is also usually an excess of urea for the first two days or so of convalescence, the "epicritical" excess. This is, in some cases, due to a retention of urea, whose amount sometimes shows a diminution towards the crisis of the fever, especially in cases characterized by the so-called 'typhoid state.'

Besides the increase of urea, there is an increase of the so-called extractives, which are nitrogenous principles of various kinds. The colouring matter is greatly increased. The salts of soda, and more particularly the chloride, are diminished, while those of potash are much increased. The phosphates and sulphates are increased.

The State of the skin during the fastigium is worthy of special attention, especially as it forms an important item in the means of regulating the temperature of the body in health. The conditions vary considerably in different fevers, and even in the same case, from time to time. In a few forms (chiefly acute rheumatism) there is usually profuse perspiration, but as a general rule the skin is, considering the temperature, remarkably dry. Even apart from this, however, the condition of the skin in regard to blood supply varies greatly, and its temperature also varies. Hence the temperature of the skin does not bear a close relationship to that of internal organs.

The Termination of fever is often by a more or less abrupt **Crisis**. It is as if the regulation of the temperature had been re-established in its normal condition, and the temperature rapidly falls to the normal. This is often accompanied by an attack of sweating, this part of the apparatus for regulating the temperature, which we have seen to be disordered, being restored to action. The other secretions are also restored at the crisis, the salivary, gastric, etc. It is remarkable how a temperature which has been for days or weeks persistently above normal, will suddenly and definitely fall, and with this all the symptoms at once improve. Sometimes, however, there is a more gradual fall of temperature, and instead of a crisis we have a **Lysis**.

Theories of pyrexia.—The very striking phenomena described above have been somewhat variously explained. In order that the different theories may be understood, let us remember the principal facts in regard to the phenomena. The rise in temperature is due directly to an abnormal combustion in the tissues, but the actual amount of heat-production is not greater than what frequently obtains in health without any rise in the temperature. The mode of heat-production is usually abnormal, implying a pathological metabolism in the tissues, but there is something abnormal also in the regulation of the temperature, as the body does not dispose of an amount of heat which it is capable of disposing of under normal circumstances.

It is acknowledged in all modern theories of fever that the abnormal heat-production is in the tissues, and is the result of increased tissue-change, and it is agreed that the regulating process by the nervous system is altered, but opinions differ in regard to the exact place which the nervous system takes in the matter. According to one view pyrexia is essentially due to the action of the nervous system, alterations in the heat-centre inducing the increased tissue-change, and at the same time changing the regulatory process. The view opposed to this is that the increased heat-production is due directly to the action of the contaminated blood on the tissues, the abnormal constituents in the former inducing increased chemical change in the latter. The altered regulation is also regarded as related to the state of the blood.

The Nervous theories of fever.—The various theories which trace pyrexia to a nervous origin are chiefly based on the facts already indicated, that injuries to the brain, whether produced experimentally in animals or accidentally in man, have been known to cause a rise in temperature, sometimes to a very high degree.

The view of Liebermeister, adopted in this country by Hilton Fagge, is that in fever the high temperature depends on a change in the normal function of heat-regulation, according to which the balance of heat-production and discharge is so arranged that the temperature is maintained at a higher level. The regulatory apparatus is at work, but it has pitched its normal at a higher level. The object of this change is a curative one. The high temperature has an influence in freeing the blood of the abnormal constituents which we have seen to be present in fever.

The view of Wood, Hale White, D. Macalister, and others is almost the converse of this. According to them the heat-centre is paralyzed by the fever-producing agent. This centre when in normal action, as we have seen, is supposed to restrain or inhibit the production of heat, and when paralyzed it allows of an over-production.

The Metabolic theory of pyrexia.—According to this theory the abnormal production of heat is due to the direct action of the fever-producing agents on the living tissues, while the due regulation of the temperature is interfered with.

To the author there are insuperable difficulties in accepting the purely nervous theory of fever. Pyrexia is produced, as we have seen, by a large number of different agents, each of which when present in the blood produces a rise of temperature. They do so also, up to a certain point, in proportion to the amount of the agent present in the blood. It seems inconsistent that such different agents should act in a similar fashion on the nervous system.

Besides, the production of heat is brought about by a process distinct from normal heat-production. In the normal production of heat in muscles, contraction is a constant if not a necessary element, and the production of heat in glands and elsewhere is associated with the performance of their function. In fever, however, the muscles are relaxed and the glands are to a large extent deprived of their function, and the production of heat is due to a destructive combustion of the tissues, and is thus abnormal in its method. It seems more probable that a morbid agent in the blood directly induces this change in the tissues, than that it should be due to a nervous influence.

This also would give us the key to the paralysis of the regulatory apparatus. This apparatus has relations on the one hand with the heat-producing functions, and on the other hand with the heat-discharging, and it is by the mutual regulation of these that the normal balance is maintained. But if heat-production proceeds from an extraneous cause, and is therefore placed outside the influence of the regulating centre, then the latter may reasonably be expected to be at fault. In addition, the fever-producing agent acts on the nervous centres as well as on other organs, and produces a certain paralysis of their functions, just as it paralyzes secretion and muscular contraction. In most fevers the cerebral functions are abnormal, although the form of disturbance varies considerably in the different fevers.

It may be a question to what extent the increased metabolism of the tissues is a reaction against the morbid agent in the blood. In this sense the rise in temperature may possibly be related to the elimination of the morbid agent, although the view that the rise in temperature in itself inhibits the morbid poison can scarcely be sustained.

Other phenomena of fever.—Most of the remaining phenomena of fever are to be brought into relation either with the rise in temperature or the direct action of the fever-producing agent.

Parenchymatous degeneration or **Cloudy swelling** is a frequent change in the tissues in fever. It affects chiefly the muscles and the secreting glands. Sometimes there is great enlargement of the liver and kidneys from this cause. The weakness of the heart, which is so marked in many fevers and may give rise to dilatation of its cavities, is, partly at least, due to this. The parenchymatous change has been ascribed to the action of the over-heated blood (Liebermeister, Wickham Legg), but this explanation is not sufficient, as it may be absent in cases where the temperature has been high (in cases of acute pneumonia) and is sometimes present without fever (Cohnheim). The action of the altered blood must be taken along with the high temperature.

The **increased rate of the pulse** is generally referred directly to the action of the rise in temperature on the heart. It is known by experiment that when the heart is artificially raised in temperature by heating the blood which is passing to it or by increasing the temperature of the surrounding air after the heart has been exposed, it beats at an accelerated rate. The **increased frequency of respiration** is also ascribed to the elevation of temperature of the blood. Goldstein, by heating the blood in the carotid so that the temperature in the medulla oblongata was raised, caused great acceleration of the respiration.

Fall of blood-pressure is a usual concomitant of fever, although it is not always present. It is present as evidenced by **Dicrotism** of the pulse in typhoid, septic, and puerperal fevers, but absent in the eruptive stages of scarlet fever and small-pox (Recklinghausen). It is to be ascribed to a general relaxation of the arteries due to a paralysis of the muscular coat similar to that of the voluntary muscles, and also to some extent to the weakness of the heart.

The **nervous disturbances** in fevers vary greatly and are only in part to be ascribed to the high temperature. In relapsing fever and in the rise of temperature which sometimes occurs in simple fractures or under the antiseptic treatment of wounds there are usually no nervous disturbances. On the other hand, typhus fever is usually accompanied by delirium; typhoid with dulness of mind, etc.; while in children convulsions occasionally accompany fever. These facts indicate that the nervous symptoms are essentially related to the pyrogenic agent, and differ according to the nature of it.

Post-mortem appearances in fever.—It will be inferred from what has gone before that there are no constant anatomical changes characteristic of all fevers. The most frequent are the parenchymatous changes already referred to, but even these, as we have seen, are not constant. In the acute specific fevers the blood is usually found after death imperfectly coagulated. As a consequence of this the hæmoglobin is readily dissolved out of the corpuscles and stains the internal surfaces of the heart and vessels; the colouring matter frequently penetrates to surrounding parts, producing frequently deep staining of the skin. The spleen is enlarged in most fevers, and it is frequently very soft, especially in typhus. Sometimes there are wedge-shaped infarctions. The liver is commonly enlarged from parenchymatous degeneration, which is frequently associated with a certain amount of fatty degeneration. The kidneys are also commonly enlarged. The muscles are liable to parenchymatous degeneration, but they are also subject to waxy or hyaline degeneration, especially in typhoid fever.

Besides these general changes, many of the individual fevers have specially localized lesions, such as the affection of the intestine and mesenteric glands in typhoid fever, of the throat in scarlet fever, of the skin and mucous membranes in small-pox, and of the soft membranes of the brain in cerebro-spinal meningitis.

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SECTION VIII.

NEW-FORMATION.

HYPERTROPHY, REPAIR, REGENERATION, TRANSPLANTATION.

New-formation of Tissues by karyomitosis. Genesis of new-formations; from indifferent cells; metaplasia. I. **Hypertrophy**, compared with normal growth; Hypertrophy (1) from congenital proclivity; (2) compensatory; (3) from increased blood-supply; (4) from direct stimulation; (5) from friction. II. **Regeneration of Tissue**; limited powers of restoration in man. III. **Repair of Injuries**; healing of wounds, restoration of blood, epithelium, and connective tissues, also nerve and muscles. IV. **Transplantation**, effected by experiment in animals, spontaneously or by operation in man.

NEW-FORMATION OF TISSUE.

THE pathological new-formation of tissue occurs by processes analogous to those concerned in the physiological formation of tissue in the process of growth.

Karyomitosis (κάρυον = nucleus, μίτος = a thread or fibre).—The new-formation of tissue, whether physiological or pathological, implies cell-division. According to the views of Rémak this process consists in a direct division of the nucleus and cell. The observations of Flemming and Strassburger show that in the growth of both animal and vegetable tissues the process is not so direct, but involves certain changes in the nucleus of a striking and peculiar nature. To this process the names Indirect division, Karyokinesis, Karyomitosis have been applied.

This process occupies a comparatively short time, seconds or minutes, and is not readily seen in the products of post-mortem examinations. In order to observe it the tissue should be obtained from the living body and immediately subjected to the proper fixing and hardening processes, preparatory to microscopic examination.

The general outlines of the process may be followed in Fig. 102. For a detailed account of the various stages the student is referred to recent histological treatises.

The **nucleus** in a state of rest is not a homogeneous body. It **ha** a limiting membrane, inside which the contents are composed of **tw** substances. One of these is deeply stained by certain **reagents, and i** hence called **Chromatic substance**, while the other is less stained **an** is called **Achromatic**. The chromatic substance forms a finely **fibrou** **stroma** (see *a*, Fig. 102) in the interstices of which the **achromati**

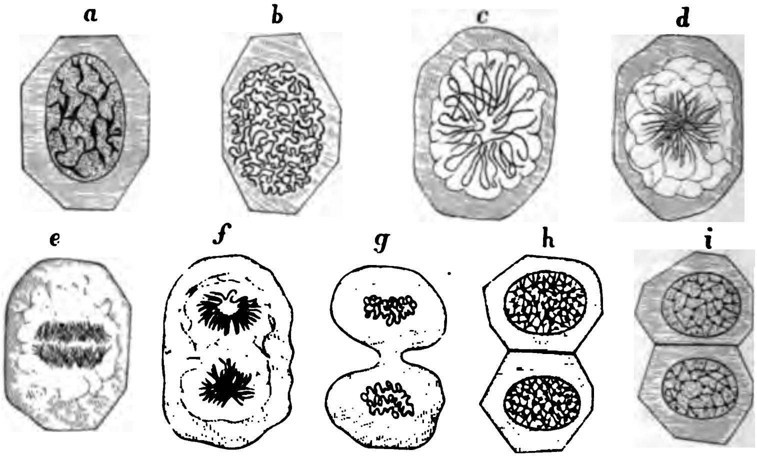

Fig. 102.—Division of cells. Explanation in text. (After Flemming.)

substance and the nucleoli lie. It is the fibrous stroma which mainly concerned in the processes which precede division. Th membrane and nucleoli disappear and the fibres become thicker ar stain more deeply than before (see *b*, Fig. 102). They also take c a more distinctly convoluted arrangement. The fibres seem to hav a power of movement since they alter their position as the proce proceeds (hence the name karyokinesis, from κάρυον = nucleus, ar κίνησις = movement). From the convoluted form the stellate form the fibres (*c*) develops, and the fibres by longitudinal division becon finer. The fibres now arrange themselves in the equator of tl nucleus (at *d* and *e*), and divide into two. The two halves no diverge from one another towards the poles of the cell, and for there the fibres of the new nuclei. At first they have a stella arrangement (*f*) which by degrees gives place to a convoluted form tion. The nucleus then subsides into a state of rest, the fibres to great extent disappear, and the cell membrane is formed. Aft the polar separation of the daughter nuclei the cell itself shows sig of division, and so the process is completed.

The process of karyomitosis is to be observed in all kinds of path logical new-formation. It is abundantly evident in growing tumours, in tubercles (according to Baumgarten), in inflammatory new-formations, and it is probably the chief, if not the only method, of new-formation of permanent cells. In fact, the activity of new-formation may in general be estimated by the number of cells in which karyomitosis is visible.

According to Arnold the process is not so uniform as that described above, but follows two types which he designates segmentation and fragmentation, but he suggests that the two may be simply modifications of the same type. There is probably, in addition to this, a direct division of cells, which occurs chiefly in leucocytes.

Genesis of new-formations.—An important question in regard to new-formations is, as to their origin and their relation to the existing tissues. It will be found that the new-formed tissue always conforms in the details of its structure to one or other of the normal tissues. No new-formation is foreign to the organism ; there is no heterologous or heteroplastic new-formation. For the most part, the new-formed tissue springs from and is in close relation with tissue of its own kind. It sometimes happens, however, in the case of tumours that their tissue extends to structures of a different nature from their own, and in this sense the term heterologous is sometimes used.

In its earlier periods, after the cleavage of the germinal vesicle, the embryo consists of a mass of round cells which, from the fact that they present no visible differentiation of structure, may be called **Indifferent cells.** Whilst they are themselves devoid of visible special structure these early embryonic cells contain in them the powers requisite for the development of the whole being of whose cells they are the parents. These cells form the three germinal layers, the epiblast, hypoblast, and mesoblast. When once this differentiation has occurred these layers remain distinct, and each produces its own special tissues. The same distinction is presumably carried out in pathological new-formations. It was, indeed, suggested by Virchow that the connective tissue which exists in every part of the body, penetrating amongst other tissues, may be regarded as the remains of the undifferentiated embryonic tissue. In this sense he regarded connective tissue as the essential agent in new-formation of tissue, and as capable of producing epithelial tissues as well as those of its own kind. In more recent times there has been a tendency to ascribe to the leucocytes which emigrate from the blood-vessels a somewhat similar position, and to ascribe at least some new-formations to the development of these cells. The general belief now is that the differentiation of the germinal layers holds for pathological as well as for physiological new-formation, and that tissues do not originate except from tissues of their own nature. The greatest difficulty in this respect is in regard to cancers, under which heading the subject will be again alluded to.

Metaplasia.—A certain interchangeability is manifested among the different tissues belonging to the connective tissue series. These really form a single tissue having certain modifications, so that fibrous tissue, bone, cartilage, mucous tissue, adipose tissue, may not only be developed to a certain extent from each other, but may even be converted, when mature, into each other. Here we have a true metaplasia. Thus, adipose tissue, by absorption of the fat, becomes loose connective tissue, connective tissue by attraction of lime-salts becomes osseous tissue, cartilage also develops into bone, or, by a different change in its matrix, forms mucous tissue.

Classification of new-formations.—The new-formation of tissue occurs under three different circumstances. It may be virtually a continuation of normal growth, the new tissue being produced to subserve the normal functions of the body. Secondly, it may occur in consequence of the application of an irritant which directly stimulates the tissues. Inflammatory new-formation is an example of this, and we have a further example in the specific or infective new-formations. Lastly, there is a group in which no cause is apparent for the new-formation; the tissue simply grows, without any apparent stimulus and without any purpose in the economy. This comprises the group of tumours proper, in regard to some of which, however, the existence of parasitic organisms as the stimulating agents has been at least suspected.

In the present section the first of these groups will be considered.

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I.--HYPERTROPHY.

The term hypertrophy means overgrowth or excessive growth. Looking to the cellular constituents of the tissues, Virchow has drawn a distinction between an increase of tissue due to an enlargement of the cells and that due to a numerical increase, applying to the latter the term **Hyperplasia**. This distinction, however, cannot be carried out, as in many cases both substantial and numerical increase may be present. The term hyperplasia may, however, be used where it is intended to convey the meaning that cell-division or proliferation is excessive.

Normal growth, as seen in the tissues during the period of adolescence, is determined by impulses inherent in the impregnated ovum. Already, at this early period, the sex and details of structure are implicitly inherent in the embryo, which enters on its career of development with a pre-determined plan. The tissues cease to grow at the period of maturity not because their powers of new-formation have been exhausted, but because this plan has been fulfilled. Hypertrophy may occur because of some error in the embryonic arrangements, or it may be due to some stimulus acting on the tissues after birth. In the latter case the effect will be greater when the stimulus is applied during the period of normal growth than after the state of maturity has been reached. In all cases the new-formed tissue is in structure and function essentially similar to the normal tissue of its kind, and forms an addition to the existing active tissue of that kind.

1. **Hypertrophy from congenital proclivity.**—There may be an excessive growth of the whole body, so that the person becomes a **giant**; or there may be a localized hypertrophy, as of the fingers, one side of the face, etc. There are also cases in which at birth there is a hypertrophy of the tongue, penis, neck, or a lower extremity.

2. **Compensatory hypertrophy.**—This form of hypertrophy implies that, as a result of some defect in the organism, some function has been called into unusual exercise. As a result of the continued excessive exercise, the tissue is increased. The necessity for this increased exercise may arise in one of two ways; there may be from atrophy or destruction an actual loss of tissue, and the remaining tissue enlarges to bring it up to the normal amount; or the circumstances may be such as to call for the exercise of a particular function in excess of what is usual, so that, in relation to the increased need, the existing tissue is defective in amount. In this case the new-formed tissue constitutes by so much an absolute excess over the average normal.

The most striking instance of compensatory **hypertrophy from loss of tissue** is that afforded by the enlargement of one kidney as a result of destruction or disease of the other. The hypertrophied kidney sometimes attains to the bulk of the two normal ones, especially if the lesion has occurred in a young person. A similar hypertrophy occurs in the lung in cases of congenital non-inflation of one lung; also in the testicle, where one is wanting or defective in its development, and in the liver, where, from destruction of a large portion of the right lobe, the left may attain to the size which the right normally presents. (See under the affections of these various organs.)

It is necessary to distinguish **Pseudo-hypertrophy** from the proper compensatory hypertrophy illustrated above. Atrophy of a tissue may be accompanied by an excessive growth of tissue different from that which has been lost, and the new tissue may not only make up the normal bulk but exceed it, so as to give an appearance of hypertrophy. Atrophy of muscle is frequently accompanied by development of adipose tissue between the ultimate fibres, and in pseudo-hypertrophic paralysis a deceptive appearance of hypertrophy of the muscles is produced. A similar excessive production of adipose tissue sometimes occurs around effete and disused glands. (See under Fatty infiltration.)

The other form of compensatory hypertrophy, characterized by **absolute excess of tissue**, is exhibited chiefly in muscular organs. In the case of canals with muscular walls, increased muscular effort compensates for defects. Thus the walls of the heart frequently hypertrophy from disease at the orifices, in the valves, or in the general vascular system. The urinary bladder shows hypertrophy of its muscular coat in consequence of obstruction at its neck (enlarged prostate) or in the urethra. The muscular coat of the stomach frequently hypertrophies from obstruction of the pylorus, and that of the intestine from obstruction of its calibre. (See under the organs named.)

3. **Hypertrophy from increased blood-supply.**—In ordinary growth of tissue, whether normal or pathological, the blood-vessels strictly follow the growing tissue, and are formed according to its needs. But if, from some accidental circumstance or by artificial interference, the blood-supply be greatly increased, then excessive growth may result. If the spur of the cock be removed from the leg and successfully transplanted into the comb, it will grow with excessive vigour, forming a prominent horn-like structure. Here the increased supply of blood, the comb having a much more active circulation than the leg, induces an excessive growth of the epidermis forming the spur.

The observations of Bizzozero and his pupils are of interest in this relation. By experiments conducted on rabbits he found that where a process of cellular new-formation by karyomitosis was going on, this was not stopped but only rendered less active by starving the animal. On the other hand the process could be greatly accelerated by increasing the blood-supply and elevating the temperature of a part. Thus in a growing rabbit the two ears were made to grow at very different rates by keeping one at a temperature of 37° C. and the other at 12° C., the difference depending essentially on differences in the blood-supply. In processes of repair and regeneration such as the healing of wounds and of fractures, the process was similarly accelerated by increase of blood-supply. When a wound was made in the ears and the one was rendered hyperæmic by extirpating the cervical sympathetic ganglion, the process of repair was more rapid in the hyperæmic one, and karyomitosis was more vigorous. Similarly in fractures of the limbs the processes of repair and regeneration were more rapid when the limb was kept at a higher temperature.

In human pathology we have numerous instances of hypertrophy from increased activity of the circulation. We see it **in the neighbourhood of inflammations**. Determination of blood exists outside the immediately inflamed area, and if this is prolonged it may lead to overgrowth of the tissues. In this way we may account for the excessive growth of hair sometimes seen in the neighbourhood of ulcers, near diseased joints, and at the ends of stumps which have remained long inflamed.

A very striking instance of hypertrophy of this kind is sometimes afforded in **bones**. In the neighbourhood of inflamed joints the surface of the bones is often nodulated, and the bones greatly thickened by new-formation under the periosteum. Again, if a child has a necrosis of the femur, the whole bone may be more richly supplied with blood, and the normal growth accelerated. The necrosis may be recovered from, and the person be left with a permanently elongated femur, which may be as much as two inches longer than the other, and this may lead to considerable lameness. The tibia is differently situated to the femur. Its two extremities are tied to the ends of the fibula by firm ligaments, and so the bone cannot freely elongate. If overgrowth occurs the bone must curve so as to accommodate itself. An example of this is shown in the accompanying Figure, from a preparation in St. Bartholomew's Hospital Museum (quoted by Paget), in which the bone, measured over its curve, was two inches longer than the healthy one (Fig. 103).

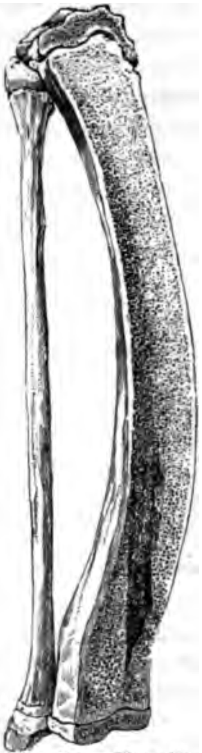

Fig. 103. — Elongation and curvature of tibia, the result of necrosis during period of growth. (Paget.)

In this connection Ribbert's views on hypertrophy may be noticed. He holds that an inherent capacity for growth is possessed by all cells, and that this is held in restraint by what he calls the "tissue-tension" of the neighbouring parts and by the influence which the body as a whole exerts on its component parts. If the tissue-tension is removed or diminished growth will take place. Hyperæmia, by separating parts one from another, will tend to lessen the tissue-tension. The inherent power of growth is thus no longer held in check, and hypertrophy is the result. As we shall see later (see under Tumours), this theory has been applied as an explanation of the origin of new growths.

4. **Hypertrophy from direct stimulation.**—From the observations of Wegner it appears that small doses of phosphorus administered to growing animals caused the epiphyseal layer of cartilage to produce

dense bone instead of spongy. The periosteum also produced bone in excess, so that increased thickness resulted. Similarly Gies observed after the administration of small doses of arsenic to growing rabbits an increase in the growth of the bones, and when administered to pregnant rabbits the young were born with both soft parts and bones larger than those of the young of rabbits of similar size. These observations of Gies have not been fully confirmed by Stockman and Greig. In these instances the phosphorus and arsenic would seem to act as direct stimulants to the bone and other tissues. Certain observers, however, hold that these changes may be the result of diminished tissue waste.

5. **Hypertrophy from pressure or friction.**—Thickenings of the epidermis occur in places where the skin is exposed to unusual pressure or friction. Continued pressure, as by a splint or bandage, causes atrophy, but intermittent pressure, by allowing the parts to recover, and by affording time for increased nutrition, gives rise to hypertrophy. We have thus the **horny hands** of workmen, and **corns**, which consist of concentric thickenings of the epidermis. The same law applies to internal parts, but as pressure from within, produced by tumours, aneurysms, etc., is usually constant, atrophy is much more frequently the result. Hence the original statement of John Hunter is justified, that pressure from without produces thickening, while that from within causes atrophy, although it is not to be taken without reservation.

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II.—REGENERATION OF TISSUE.

The term **Regeneration** is applied to the restoration of portions of the body which have been lost by injury or disease. The regeneration of a part is to be carefully distinguished from mere growth or hypertrophy. A tissue may be able under suitable stimulation to reproduce its elements, and increase in size; but for the replacement of a lost part, if at all considerable, there must be, virtually, a renewal of the process of development. To effect this renewal of development the cells of a part must carry with them a considerable share of the original germinal material by the action of which the animal was *formed* in the process of development. Such an extension of the determining power occurs very extensively in plants which seem in most of their parts to have the powers of formation of the whole. In the animal kingdom it is much more limited.

The **reproduction of lost parts** in their entirety occurs readily in some of the **lowest forms of animals**. In the hydra, if the creature be cut in two, each half will develop into a complete animal, and the process may be repeated indefinitely. This power of reproduction of the whole animal from a part seems confined to those creatures which, like plants, can propagate by spontaneous fission or gemmation. When we come to animals higher in the scale the power of reproduction seems to be limited to the restoration of lost limbs, antennæ, etc.

Without going into details, which will be found in Paget's "Lectures on Surgical Pathology," it may be said that there are indications which seem to show that there is some kind of law according to which the reparative power in each perfect species is in inverse proportion to the amount of change which the animal has passed through in its development from the embryonic to the perfect state. It is as if, in the process of development, the formative power as distinguished from mere growth were gradually exhausted, and the process of reproduction, which we have seen to be, as it were, a renewal of that development, only occurs when this power has been comparatively little expended. It appears, for instance, that in insects the power of reproducing antennæ or limbs is limited to those species which have attained the perfect state through a comparatively simple and direct course of development. It is consistent with this view that in the larval state insects show a much greater power of reproduction than when perfect. The larva of one of the higher insects is able to reproduce its limbs, while the perfect insect is not.

In man, and in the vertebrata in general, the long course of development seems largely to exhaust the reproductive power of the body, and, in the adult state at least, the power of restoration of lost parts is very limited, and the processes concerned are almost as much related to growth of tissue as to development. In the embryonic state it is probable that the power of restoring lost parts is much greater than in the adult. Some children are born with a short arm, at the extremity of which are imperfectly developed fingers; it is probable that in these cases amputation of the arm has occurred *in utero*, and an attempt at restoration has followed.

In the **human being after birth** it may be said that restoration of lost structures is almost confined to the epithelial and connective tissues and to the blood. Along with the connective tissues we have, of course, blood-vessels, which are readily reproduced, and we may also, to a limited extent, include nerve-fibres, which, as we shall see afterwards, are sometimes restored.

The blood is gradually regenerated when in consequence of hæmorrhage its bulk is reduced. The fluid portion is rapidly restored, the white corpuscles are also soon replaced, but the red corpuscles somewhat more slowly. (See Anæmia.)

The epithelial structures of the body are to a large extent continually undergoing a physiological process of loss and regeneration. The hairs of men and animals fall out at intervals and are restored; the feathers of birds undergo a similar process; the nails and horny layer of the epidermis are continually lost and replaced by new-formation. The plucking out of hairs or feathers, or the removal of nails is followed by their restoration, so long as the papillæ are not destroyed. It is an interesting fact that when the whole distal phalanx of the finger is removed, or even the two terminal phalanges, there may be a partial restoration of the nail in that which has become the terminal phalanx. There is also a case recorded in which a boy, apparently affected with ichthyosis, regularly shed his nails. (See references in Recklinghausen.)

On the general surface of the skin and mucous membranes there is normally a continuous shedding of the surface epithelium, and a karyomitosis in the deeper layers to replace that which is lost—a kind of physiological regeneration. When, by accident or otherwise, a superficial portion of epithelium is shed before its time, it will be replaced by the requirements of the body. When the whole thickness of the epithelium is destroyed the gap is by degrees filled by the proliferation of the epithelium at the edges of the wound, as we have already seen in the case of the cicatrization of a granulating wound. According to the observations of Klebs the new-formed epithelium acquires a slight power of amœboid movement, so that it can proceed to the spot which it is to occupy.

The proliferation of the epithelium proceeds by the process of karyomitosis. In the accompanying illustration (Fig. 104), the fibrous transformation of the nucleus and the other changes, as seen in the cornea of the rabbit, some days after a portion of the epithelium had been removed, are shown. In the normal cornea and in the Malpighian layer of the epidermis there are evidences of a similar process by which, we may presume, the physiological regeneration occurs.

Gland epithelium also to some extent undergoes a physiological loss and regeneration. The secretion of some glands implies a destruction of cells and their restoration. According to Bizzozero, who examined the various glands with respect to the activity of karyomitosis, the sebaceous glands, the mucous glands of the stomach, Lieberkühn's glands in the intestine, and the uterine glands, are actively engaged in regenerating their epithelium, and consequently lose it in the process of secretion. In glands which normally present an active new-formation of their epithelium it is not surprising that regeneration occurs when parts are lost, but even in the kidney and liver where there is no such normal proliferation, loss by disease induces a new-formation. Thus in acute nephritis the epithelium is to a large extent shed, and we may find desquamated epithelium lying in the tubules, while young epithelium lines them. In acute yellow atrophy of the liver also, there is great destruction of the hepatic cells, and there is often visible along with that a new-formation of cells as if there were an attempt at restoration. In both of these organs also, a loss of substance induces a new-formation, which may be regarded either as a compensatory hypertrophy or a regeneration. Large portions of the liver, removed experimentally, are in time reproduced. The epithelium of the thyroid gland, urinary bladder and gall-bladder is capable of considerable local regeneration.

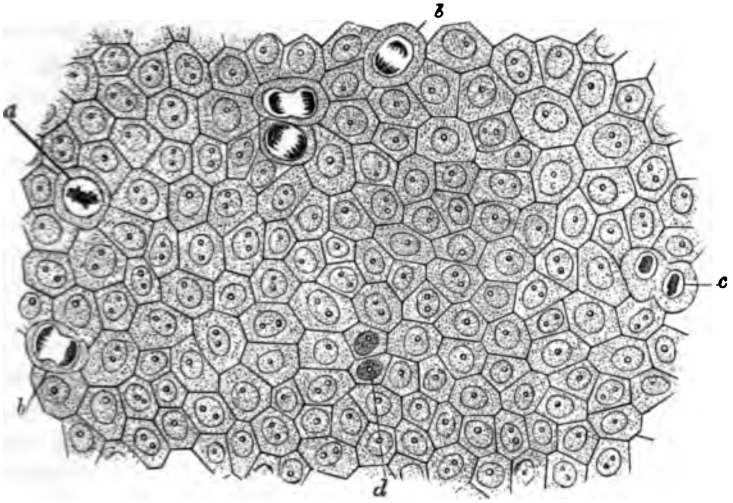

Fig. 104.—Regeneration of epithelium in cornea of a rabbit. *a*, Fibrous transformation of nucleus; *b*, partial separation of the fibres and hour-glass change of nucleus; *c*, complete division of nucleus; *d*, complete division of cell. (Eberth.)

The lens of the eye, which in its development is an epithelial structure, may be in part or in whole regenerated, after its removal on account of cataract. The epithelium of the **cornea** is also capable of reproduction.

Connective tissue, as we have seen, is frequently regenerated, and the new-formed tissue is the means of union of wounds. **Blood-vessels** are similarly restored, forming really part of the connective tissue.

Cartilage seems scarcely capable of regeneration, at least in the adult. Fractures of the cartilaginous ribs are united by bone, and wounds of cartilage are replaced by connective tissue or bone. Experiments on young animals show that in them there may be considerable regeneration, and it is probably so also in the human subject.

Nerve-fibres are regenerated after division of nerve-stems. A simple section of a nerve may be followed by immediate union, and the function may be restored in a few days. Even when portions of nerves have been removed (as much as 2 inches) there is a restoration of function, but at a much longer interval. The division of a nerve, unless there be immediate union, implies, as we shall see further on, a remarkable change in the whole peripheral portion from the point of section onwards, and when restoration occurs there is a regeneration of the axis-cylinder apparently by growth outwards from the central end. The power of regeneration and accommodation of nerves is further shown by the fact that, after transplantation of skin, when the parts are separated from their nervous connections there is a restoration of sensation.

Muscle is, to a limited extent, liable to regeneration. Wounds of muscles are usually united by connective tissue, although subcutaneous wounds, as proved by experiment, often heal without cicatrix. Weber found also that in the neighbourhood of fractures no cicatrices existed in the muscles, although they had undoubtedly been torn by the ends of the bones. In the healing of wounds in muscles by granulation, it is believed by some that a new-formation of muscle takes place to some extent, the muscle nuclei taking part in the process. There is also a restoration of muscle after atrophy and degeneration. In emaciating fevers there is a great atrophy of the voluntary muscles and a restoration as convalescence advances. Fatty degeneration of muscle is probably followed, as in other cases of fatty degeneration, by absorption of the affected structures, and this again involves a regeneration. In these cases the muscle nuclei are not lost, and they seem to be the agents in regeneration. The regenerative power of unstriped muscle and of the muscle of the heart is very limited.

III.—REPAIR OF INJURIES.

While the absolute restoration of complete and considerable portions of the body is scarcely possible in man, yet the body is by no means unprovided with powers by which injuries are repaired and loss of structures is made good. It may be said that the higher and more complex animals are endowed with greater ability to protect themselves from injury, and that their tissues possess the necessary powers of restoration in the case of those injuries to which they are specially liable. In the various processes here to be considered, it will be seen that what may be called the definite intention to attain a certain result which is shown in the process of development, is distinctly visible, and that the tissues have a remarkable power of meeting adverse conditions.

Healing of wounds.—The power of repair is well seen in the various processes concerned in the healing of wounds. There are some wounds which heal by a process fitly designated **Immediate union.** That is to say, the surfaces are brought together and coalesce without any new-formed material being produced to serve as a bond of union. This occurs mostly in clean-cut wounds, which, shortly after their infliction, are closed so as to bring the cut surfaces into close contact. It is necessary for this process that all inflammation be avoided either at the time of infliction of the wound or afterwards. We must think of the living tissues not as mere mechanical pieces of texture, but as possessed, by virtue of their vitality, of wonderful powers of adaptability to circumstances. When two living surfaces are brought into contact and all disturbing conditions are averted, then the blood-vessels form communications, the nerves by and by unite and become continuous, and the connective tissue coalesces. In all this there is a certain amount of new-formation by karyomitosis, and there may even be slight inflammatory exudation, but there is no permanent new tissue produced, and a wound in the skin, or even in muscle, may unite, and no trace of a bond of union or even of the line of union can be found after a few days. The epidermis probably does not unite so directly, and the wound is covered by new-formed epidermis.

Primary adhesion is a process of a more complicated kind. In it inflammation plays a part. When a wound is inflicted the mere mechanical injury, or exposure afterwards, frequently leads to a trivial but acute inflammation, resulting, as we have seen, in the coating of the cut surface with a fibrinous exudation, the so-called glaze. If two surfaces thus coated with fibrine be brought in contact they unite, the fibrine acting as a glue or cement. But the fibrine does not form a permanent bond of union, and if union is not effected by other methods, then the wound will subsequently gape by the breaking down of the fibrine. In order to effect a permanent union we must have formative cells produced, such as are concerned in the formation of connective tissue out of granulation tissue, and we must have a new-formation of blood-vessels. The uniting tissue is very trivial in amount; there is merely a limited production of formative cells which replace the thin layer of fibrine, and a budding of the blood-vessels till communications are formed between the two surfaces. This whole process may occupy only a day or two, and the permanent new-formed tissue forming the cicatrix is usually very small in amount.

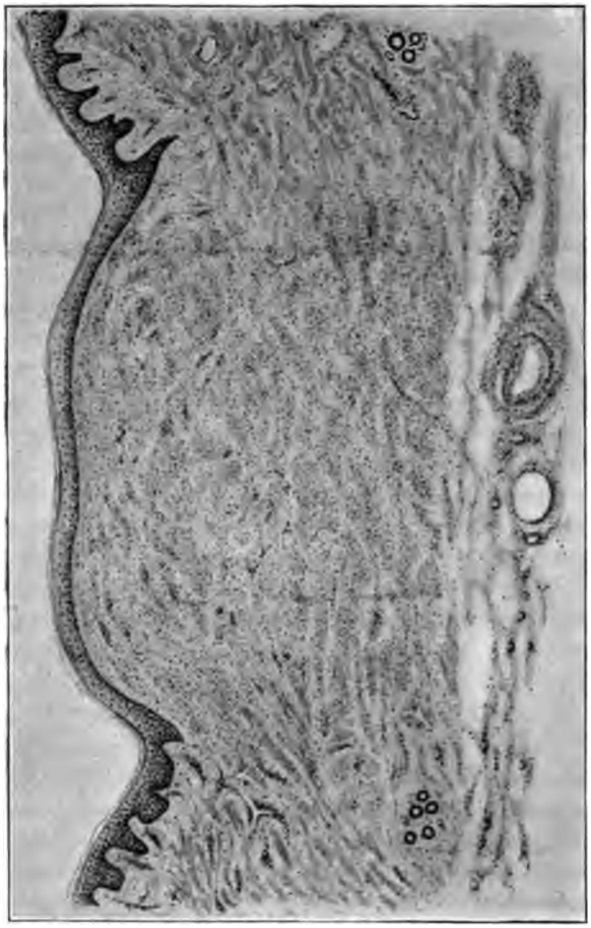

Fig. 108.—Healed wound of skin. The scar is raised above the general surface and covered with a simple epithelial layer. × 40.

The term **Union by the first intention** is commonly used so as to include both of the conditions described above, any case of union occurring upon application of the two surfaces soon after the infliction of the wound being so designated. (See more fully in Paget's "Surgical Pathology.")

Union by the second intention or **by granulation** is a name given to the closure of a wound by the adhesion and coalescence of two layers of granulations. We have already seen how this comes about. The granulations ultimately develop into connective tissue which forms the cicatrix or permanent bond of union. In this case the cicatrix is a much more considerable one than in union by the first intention. (Fig. 105.)

IV.—TRANSPLANTATION.

By this term is meant the removal of parts of the living tissues from their normal position, and their implantation in another situation. This process has been frequently effected by experiment in animals; it is of occasional occurrence as a pathological phenomenon in man, and it is sometimes made use of for therapeutic purposes as a surgical operation.

The best known experiment is the transplantation of the spur of the cock to other parts of the skin or to the comb. Zahn implanted a whole fœtal femur into the kidney of an adult rabbit, and found that it survived and grew there. Bert performed many experiments, in which he removed the tails of rats and implanted them on their backs. A remarkable fact brought out in these experiments was, that if the implantation was made with inversion of the tail, so that the tip was in the back and the root projected out, yet the tail survived, and even sensation was restored, conduction occurring in the nerves in the reverse direction.

Several practical results arise from these experiments. For one thing, the larger the surface by which the transplanted piece was in contact with the living tissue, the greater the likelihood of success. Hence, small pieces of tissue and those which were completely buried in the living tissues were the most successful. In experiments with rats' tails, the latter required to be denuded of skin for some distance, so as to bring a considerable raw surface into contact with the subcutaneous tissue. Another fact was, that tissues from young animals were more successfully transplanted than those of adults. Again, the transplanted piece commonly grew in its new situation, sometimes very markedly, as in the case of the cock's spur on the comb. This growth, however, was generally temporary, and in many cases was succeeded by diminution and complete absorption of the transplanted piece. If the transplanted piece, however, was so placed as to restore a lost part, then it remained permanently. Lastly, the tissues of animals of different species did not seem congenial, so that when, for instance, the tissues of rats were transplanted to birds they gave rise to severe inflammations (Ollier).

In **man**, transplantation sometimes occurs **spontaneously**. The greatest example of this is furnished in some cases of **Tubal pregnancy**, in which, after rupture of the tube, the ovum may be transplanted to the peritoneum and, acquiring adhesions there, develops its placenta in connection with the vessels of the peritoneum. **Tumours** of the uterus or ovary (myomata and cysts) also sometimes separate from their seats and acquire connections with other parts. It is probable that in these cases there is a gradual transplantation, the new connections being formed before the old are completely severed. Again, portions of tissue are sometimes **broken off**, such as the appendices epiploicæ in the peritoneum, or portions of synovial membrane, cartilage or bone in joints. These may become free bodies, retaining their vitality without any vascular connections, or they may become attached in new positions.

Transplantation, as a **Surgical operation**, has long been practised. In plastic operations, involving the surface of the body or the buccal cavity, the transplantation is usually partial, the transplanted piece being left, at least for a time, in partial connection with its original seat. A complete transplantation is effected in **skin-grafting**, in which portions of the living epidermis are transplanted to the surface of granulating wounds. The granulating surface, being exceedingly vascular and composed of cells, very readily coalesces with any living structure placed on it.

Transplantation of bone is an interesting achievement of modern surgery. Macewen has succeeded, by successive transplantations, in restoring almost the whole shaft of the humerus, which had been lost by necrosis, and he has also shown that, after trephining the skull, the piece removed may be restored, and it will retain its vitality and acquire fresh connections. (See further under Affections of Bones.)

Literature.—Paget, Lect. on surg. path., ed. by Turner, 1870; Hunter, l. c.; Ranvier, Le dévelop. du tissu osseux, 1865, and in Cornil et Ranvier, Manuel d'hist. path., 1881, i.; Kennedy, On the regeneration of nerves, Phil. trans. Royal Society, ser. B, vol. 188, 1897. Ballance and Stewart, The Healing of Nerves, 1902. Aschoff (with literature), Lubarsch and Ostertag, Ergebnisse, 1900. Marchand (with literature), Der Process der Wundheilung, Deutsche Chirurgie, 16, 1901. *Transplantation*—Recklinghausen (very fully), Allg. Path., 1883; Hunter, Works by Palmer, iii., 273; Zahn, Congrès périod. internat. Genève, 1877; Bert, Annal. de science nat., v., 1866; Reverdin, Gaz. d. hôpit., 1870-71, Arch. gén. de Méd., xix., 1872; Macewen, Phil. trans. of Royal Soc., 1881, and Annals of surgery, Oct. and Nov., 1887. Marchand, loc. cit., 1901.

SECTION IX.

TUMOURS OR MORBID GROWTHS.

INTRODUCTION.

Definition.—**Structure**, typical or atypical. **Causation**, Cohnheim's theory of origin; Ribbert's theory; inheritance; effect of injuries, etc.; parasitic microbes; influence of age. **Growth and Extension**, typical or atypical; local malignancy; metastasis and generalization of tumours; occasional malignancy of typical tumours. **Classification and Nomenclature.**

A TUMOUR means literally a swelling, and formerly any swelling was called a tumour. *Tumor*, for example, is often named as one of the cardinal signs of inflammation, and it is still customary to speak of the inflammatory tumour. But the modern use of the word is limited to a class of new-formations of which it is difficult to give a strict definition.

It may be said that tumours are pieces of tissue which have a life and growth of their own irrespective of the needs of the organism, and of the local conditions around them. In the elements of their structure, tumours do not differ from normal tissues. They are nourished by the same blood, the blood-vessels are continuous with those of surrounding parts, the nerves are connected with neighbouring nerve stems, and the tissue, although not always the same, is frequently identical with that near it. But it grows independently and without apparent object. Thus a fatty tumour goes on increasing in size irrespective of the adipose tissue in which it has its seat, and the person may be reduced to the greatest emaciation, most of the ordinary fat being absorbed while little or no impression is made upon the fatty tumour.

Structure of tumours.—While all tumours in their ultimate structure are analogous to the normal tissues, yet some of them vary considerably from the type of tissue to which they belong. Hence, it is possible to distinguish tumours whose structure is **Typical**, and others whose structure is **Atypical**. In the former, the details, including the size and shape of cells, the abundance of cells, the relation to intercellular substance, and so on, are all within the limits of the corresponding normal tissue. In the latter the structure varies from the normal, chiefly in respect that the cells become much more numerous, and that the intercellular substance becomes less obvious. We shall see later that in their *mode of growth*, tumours show somewhat similar differences, some being typical and some atypical, and that in general the variations in mode of growth correspond with those in structure.

The terms **Homologous and Heterologous** were at one time employed to express the idea that the structure of a tumour may, or may not, correspond with that of the tissues of the body, the heterologous tumours being looked upon as altogether different in structure and foreign to the body. In the modern use of the words a homologous tumour is one which exists in tissue of its own kind, as an osseous tumour growing from bone. A heterologous tumour on the other hand is one which is present in a situation where no normal tissue of that kind exists, as, for example, an osseous tumour in the brain.

Causation of tumours.—It is implied in the definition given above that the causation of tumours is exceedingly obscure. For the most part, without any apparent stimulus, they begin to grow, and go on growing without control.

An explanation of the origin of tumours, which may apply to some tumours but certainly does not account for all, has been advanced by **Cohnheim**. He suggests that the primordial tumour is a piece of tissue, which in the process of normal development and growth has been, as it were, left over. It has been left embedded in the tissues, and having retained embryonic powers of growth is not subject to the general laws which control the growth of normal tissues.

In enforcing his argument Cohnheim points out that pieces of living tissue, especially if from young animals, will bear transplantation, and, if placed in a favourable situation, may grow to considerable dimensions. Thus, the spur of the cock, transplanted to the more vascular comb, will sometimes form a considerable tumour, and Leopold has shown that if cartilage from an early fœtus be transplanted into the anterior chamber of an eye it acquires vascular connections with the iris and forms a tumour of some size. The earlier the period of development of the fœtus the more likely is there to be a vigorous growth.

Certain facts in the pathology of tumours themselves lend some support to this view. Thus cartilaginous tumours not infrequently originate in bones, as if portions of the original fœtal cartilage had been left over and had afterwards grown. Then there occur in the subcutaneous tissue, tumours composed of mucous tissue, a form of tissue which in the embryo occupies the place of the subcutaneous fat. It is as if portions of this fœtal tissue had been left over from the embryo and formed the nucleus of the tumour. Then also tumours not infrequently develop from congenital moles or soft warts. These little outgrowths have commonly a rudimentary or embryonic structure (see section on Skin Affections); they may lie quiescent throughout life, and only occasionally start into vigorous growth.

While Cohnheim's theory may apply to some tumours, more particularly to the typical ones, it does not explain a large proportion of cases, and especially the cancers. In these the existing normal structures, usually in an increasing area, give rise to the tumour. There must be here some stimulus acting on the epithelial structures especially.

More recently a theory of tumour-formation has been brought forward by **Ribbert**. According to this observer, as we have seen (see page 261), there is in every cell a capacity for growth which is held in check by the "tissue-tension." If cells or groups of cells are completely or partially separated from their organic continuity the restraining action of the tissue-tension is removed and they proliferate. Thus tumours may arise. This may be illustrated in the case of cancer. Here, according to Ribbert, it is the connective tissue stroma which plays the leading part, and not, as most observers hold, the epithelial elements. In cancer there is an alteration in the tissue-tension. The inherent capacity for growth of the connective tissue is in the first instance set free. The growing connective tissue invades the epithelium breaking it up into groups of cells, which becoming in their turn freed from the restraint of the tissue-tension, proliferate and under favourable circumstances give rise to tumours. The isolated cells retain unaltered all their inherent properties during proliferation. The theory has been made applicable to all forms of tumour-formation, simple as well as malignant. Its great disadvantage lies in the fact that it can so seldom be put to the proof, and for this reason mainly it has been by many adversely criticised.

Inheritance is generally believed to play an important part in the causation of tumours. The embryonic tissue presupposed in Cohnheim's theory may, like an ordinary malformation, be transmitted by inheritance, or the predisposition to the abnormal growth in cancer may be so transmitted.

The whole subject of inheritance of tumours stands in need of elucidation. It is asserted on the one hand "we cannot overestimate the importance of inheritance in the origination of cancer" (Paget), while on the other hand it is asserted that when the families of non-cancerous persons are compared with those of cancerous, there is little or no appreciable difference in the number of cancerous relatives (Snow, Cripps). We have already seen that so far as we are able to go on demonstrable facts, inheritance deals with local peculiarities of structure. It is stated by Paget that in the transmission of cancer, the disease often passes from one situation to another, as from the breast to the stomach or uterus. This author would even seem to indicate that in transmission a cancer may become a sarcoma. Such statements run so counter to the known facts of inheritance that they throw considerable doubt on the whole subject. The strongest arguments in favour of inheritance are based on the observation of individual families, such as those recorded by Paget, Broca, and others.

Injuries, Irritations, and Chronic inflammations play an important part in determining the occurrence of tumours. Thus, fractures of bones are sometimes the starting points of cartilaginous or bony tumours or of sarcomas. Cancers of the mamma are often referred to blows on the breast. The seat of election of cancers is often determined by the local conditions of exposure to irritation by friction or otherwise. For example, cancer of the lip and tongue are referred to irritation by a tobacco pipe or carious tooth; cancer of the stomach is often ascribed to prolonged irritation from alteration in the gastric juice. The frequency of cancer at the narrow parts of mucous canals, such as the pyloric orifice of the stomach, the ilio-cœcal valve, the os uteri, has also been ascribed to their special exposure to irritation.

Parasitic microbes have been suspected as forming the determining causes of tumours, but without any definite proof. We have seen that specific microbes are the exciting causes of the infective tumours, and the analogy between their mode of growth and that of malignant tumours, such as sarcomas and cancers, has led some to suppose a similar causation. An important distinction must be drawn, however, between the infective characters of the tumours due to parasitic microbes and those of tumours proper. In the former case, the infectiveness is due to the extension of a parasite, which, wherever carried, induces an effect comparable to inflammation, but with certain specific characters. The lesion is the result of irritation of the tissue to which the parasite is applied. In the case of a tumour, on the other hand, there is everywhere a proper new-formation of tissue, which of its kind is completely organized, and not merely an effect of irritation. Even when produced at a distance from the primary tumour, the secondary one is, in the details of its structure, an exact reproduction of the tissue of the original growth. Thus, while cancers differ very greatly in structure according to their seat of origin, they always, so to speak, breed true; the secondary tumours, however various their seats, having the same structure as the primary one.

Whilst ordinary microbes seem incapable of producing such results, it must not be denied that facts recently observed point to the possibility of animal parasites belonging to the protozoa having to do with the causation of atypical tumours. An animal cell of a parasitic character may enter into conjunction with the living cells of the tissues, and lead to peculiar stimulations of the latter. (See under Cancer.)

Age is a factor in the etiology of tumours. The frequency of tumours increases in proportion to the persons living up to the age of seventy, and is greatly increased from thirty upwards. This latter fact is due to the prevalence of cancer in the more advanced years of life. Cancer is a disease of decadence.

Growth and extension of tumours.—Most tumours enlarge by a new-formation of tissue within themselves, just as the normal tissues increase during the period of growth. Their growth is **typical**. The tissue of the tumour is sometimes continuous with that of surrounding parts, sometimes it is separated by a capsule composed of connective tissue; sometimes it begins by being continuous and afterwards gets separated. In any case the ordinary tumour simply grows by new-formation of its own tissue. It often produces effects on neighbouring parts, by pressure especially, but apart from these merely mechanical effects, it does not prejudice neighbouring structures. Tumours possessing these characters are usually called **Simple** or **Innocent growths.**

There are tumours of which this is not true. They have a tendency to grow into and infiltrate neighbouring tissues, presenting characters of what may be designated **Local malignancy**; their mode of growth is **atypical.** This is peculiarly the case with sarcomas and cancers. In the case of sarcomas the tumour seems to penetrate into and develop, as it were, on the mould of the existing tissue—apparently very much in the style that granulation-tissue grows into and moulds itself on a thrombus or a piece of catgut in the tissue. In the case of cancers, on the other hand, their tissue, which is epithelial in character, penetrates among the tissues, largely destroying them and producing inflammatory disturbances.

Besides this local malignancy the same classes of tumours frequently show a still more atypical growth by extending beyond their local seat. This character is expressed in the term **Metastasis**, which is another feature of malignancy. In this case secondary growths spring up in parts removed from the primary tumour, and doubtless something is carried from the original tumour to the remote part. In the case of cancers the epithelial processes penetrating into the tissues readily find their way into the lymphatic spaces, and portions may be carried thence to lymphatic glands.

Besides this metastasis by the lymphatic system, there is sometimes a more distant metastasis by the blood, in which case the tumour is transplanted to various parts of the body, and the term **Generalization** is used. This occurs usually after the lymphatic glands have been involved, but in sarcomas it is usually direct, the tumour penetrating through the walls of the vessels. It is mostly the veins which are thus opened into, and the first extension is therefore to the lungs, but the pulmonary capillaries may be in part traversed, and implantation occur by the systemic arteries.

The material which passes from the tumour and is thus transplanted is undoubtedly the living cells of the tissue, together with such parasitic or other agents as may be proved to co-exist. This is clearly demonstrated in secondary cancerous infection of the peritoneum where the secondary tumours are not regularly distributed over the peritoneal surface, but occur here and there, or in groups, just as if solid particles had been carried and produced their effects where they got leave to lie. Then also it must be solid particles which are arrested by the lymphatic glands and give rise to the secondary tumours there.

In this connection it is important to note that the secondary tumour for the most part exactly reproduces the tissue of the original one, even to the smallest details, and it is natural under these circumstances to believe that pieces of the original tumour are actually transported.

Occasional malignancy of typical tumours.—It has already been stated that sarcomas and cancers are the tumours which regularly present a malignant tendency, but on rare occasions other tumours also do so. **Cartilaginous tumours** are not infrequently malignant. Next to them mucous-tissue tumours most frequently become malignant, but even fibrous tumours have been observed to do so, and cases of colloid goitre have been recorded in which secondary tumours occurred. So that malignancy is not confined to sarcomas and cancers. On the other hand, tumours having the structure of sarcomas may remain local to the end.

It has been usual to believe that malignancy is dependent on peculiarities of the tumour itself, and it is true that when a simple tumour, as sometimes happens, assumes malignant characters, it usually assumes the structure of a sarcoma or cancer. An attempt has been made, based on the views brought forward by Thiersch as to the causation of cancer (see under Cancer), to account for the difference between a simple and a malignant tumour. In the case of a simple tumour the normal tissues are able to prevent the tumour-tissue from penetrating into them, but in the case of malignant tumours the tissues have become weakened and are unable to form a barrier to their extension. When a simple tumour becomes sarcomatous, it is because the tissues around have acquired a peculiar weakness. When pieces of a tumour are transported to a distance, a struggle, as it were, occurs between the tendency of the tissue of the tumour to grow, and that of the normal tissues to prevent its growth. In the case of a simple tumour the tissues assume the upper hand, and cause the absorption of the tumour-tissue. In the case of malignant tumours, however, the tissues are too weak to accomplish this, and the secondary tumour develops. This theory is not sufficient to explain all the facts, and we must suppose as well a special power of growth in the tumour. No doubt the tissues differ very greatly in their power of restraining the growth of secondary tumours. In the liver, for instance, cancers grow very freely, and attain large dimensions, but looking to a cancerous liver, it is difficult to believe that there is not a special activity in the growing tissue of the tumours.

Secondary changes in tumours.—Tumours are exposed to the same pathological processes as normal tissues, and in a higher degree. Thus we meet with fatty degeneration, especially in quickly growing tumours; calcareous infiltration in structures which are obsolete; hæmorrhages, principally in superficial rapidly growing tumours, where the blood-vessels are ill-formed; and necrosis mostly in tumours near the surface, and thus exposed to mechanical irritation, the consequences of such necrosis being ulceration with, it may be, suppuration, hæmorrhage, or decomposition.

Conditions like those last named seriously affect the organism as a whole, and they occur most frequently in the case of malignant tumours, which grow quickly and rapidly come to the surface. Malignant tumours also affect the organism as a whole by the readiness with which they extend to or produce secondary tumours in important organs, and secondary cancers frequently also induce inflammations as in the case of the peritoneum or pleura.

It is clear, therefore, that malignant tumours, especially by bleeding, by ulcerating and sloughing, by invading important parts, by producing inflammations, etc., have a tendency to impoverish the system, producing anæmia and general weakness. If growing quickly they also tend to emaciate by using up the nutritive material of the body. A simple tumour, if it happens to be at the surface and exposed to mechanical violence, may also ulcerate and produce serious constitutional results, but this is exceptional. To these conditions of the body as a whole the name **Cachexia** is often given.

Classification and nomenclature of tumours.—Tumours have sometimes been classified and named according to their clinical characters, whether innocent or malignant, the term cancer being used to include malignant growths in general. A true system of classification will take into account the origin, structure, and mode of growth of tumours, and such a classification will be found ultimately to correspond with clinical facts.

In classifying tumours according to their origin we may assume that they take origin in tissues of their own nature. This is at least admitted in the case of simple tumours; a fatty tumour, for example, originates in adipose tissue. In the case of cancers, whose more important elements are epithelial, Virchow asserted that they originated from connective tissue. This was opposed by Thiersch, who showed that in the case of epithelial cancer the cells originate from existing epithelium. This view has been amplified by Waldeyer, who, in a very elaborate series of investigations, has shown that in their very various seats, cancers are in their origin connected with epithelial structures. This has led to a reference to embryology in the classification of tumours. An attempt has been made to distinguish those arising from the various layers of the embryo, the tumours of mesoblastic being separated from those of hypoblastic or epiblastic origin. It is very difficult to carry out this distinction absolutely. The epiblast gives rise to much besides epithelium, as does also the hypoblast, and there seems even now considerable doubt whether the serous cavities are hypoblastic or mesoblastic, and whether, in consequence, the layer of cells covering these cavities is endothelium or epithelium. The attempt to carry out rigidly this mode of classification has led to great difficulties in the nomenclature and placing of some tumours. Thus we have tumours of the pleura and peritoneum, which have the structure of cancers, but many authors regard the endothelium of these cavities as belonging to the connective tissue, and many of them would place such tumours amongst those arising from connective tissue, and separate them from the cancers.

The structure and mode of growth have to be taken into account as well as the origin of tumours. It has been indicated above that in respect to structure and mode of growth tumours may be typical or atypical. It will be convenient to divide tumours, in the first instance, on this basis into two great groups, the typical and the atypical. In the further subdivision of these groups the relation of the tissue to the corresponding normal tissue is taken into consideration, and we have both typical and atypical tumours referable to the same normal tissue.

The grouping of tumours into typical and atypical forms will nearly correspond with the clinical distinction of innocent and malignant, but it must not be forgotten that the distinction is not absolute, and that typical tumours sometimes assume the characters of the atypical.

In naming tumours the structure is chiefly taken into account. The typical tumours are named by adding the usual suffix *-oma* to the name of the tissue. The atypical tumours have special names which are variously derived. Thus, Sarcoma is a name originally used in a very indefinite way, but by Virchow applied to atypical connective-tissue tumours. Carcinoma also had at one time a wide and somewhat indefinite significance, but is now limited to atypical tumours whose more important structure is epithelium.

A very great advance was made in our knowledge of tumours by the publication of Virchow's classical work, "Die krankhaften Geschwülste." From this work some of the following illustrations are borrowed by the kindness of the author.

Literature.—J. Müller, Bau und Form der krankhaften Geschwülste, 1838; Virchow, Die krankhaften Geschwülste, 1864-67; Paget, Lectures on Tumours, 1852, Surgical Pathology, 3rd ed., 1870, Path. trans., xxv., p. 319; Lucke, in Pitha and Billroth's Handbuch, vol. ii., part 2, 1869; Cohnheim, Allg. Path., 2nd ed., vol. i., 1882; Broca, Traité des Tumeurs; Butlin, Art. Tumours, Internat. Encycl. of Surg., vol. iv., 1884; Zahn, Congrès méd. internat. de Genève, 1878; Leopold, Virch. Arch., lxxxv., p. 283; Baker, St. Barth, Hosp. Rep., vol. ii., p. 129; Cripps, do., vol. xiv., p. 287; Snow, Clin. notes on Cancer, 1883; Thiersch, Epithelialkrebs, 1865; Waldeyer, Volkmann's Sammlung, No. 33, 1872, Virch. Arch., xli. and lv.; Coats, Path. trans., xxxviii., p. 399, 1887; Ribbert, Das pathologische Wachstum., 1896, article in Bibliotheca medica, 1897; Lubarsch (with copious references), Lubarsch and Ostertag, Ergebnisse, 1895, 1897, 1901; Borst, Die Lehre v.d. Geschwülsten (with atlas), 2 vols., 1902. Here the recent literature of the various forms of tumour is fully given.

SECTION IX.—CONTINUED.

A.—TYPICAL OR HISTIOID TUMOURS.

1. **Fibroma**, hard fibroma, soft fibroma, cutaneous outgrowths, elephantoid hypertrophy, molluscum fibrosum; 2. **Lipoma**, diffuse and encapsuled varieties; 3. **Myxoma**, characters of mucous tissue; hydatid mole; the myxoma, varieties of; 4. **Chondroma**, as ecchondrosis or enchondroma, the latter usually in connection with bone; 5. **Osteoma**, chiefly as exostosis, Odontoma; 6. **Myoma**, the rhabdomyoma rare, the leiomyoma common, structure and relations of latter, Wood's painful subcutaneous tubercle; 7. **Neuroma**, the true Neuroma; 8. **Angioma**, capillary, cavernous, lymphatic; 9. **Glioma**; 10. **Psammoma**; 11. **Lymphoma**; 12. **Papilloma**; 13. **Adenoma**, of varying structure according to gland; 14. **Cystoma**, cysts arising from pre-existing cavities, including retention cysts; and cysts of independent origin, including dermoid cysts, adenoid cystoma, extravasation cysts, etc.; 15. **Teratoma**.

1.—THE FIBROMA OR CONNECTIVE-TISSUE TUMOUR.

THIS is a tumour composed of white fibrous tissue. Yellow elastic tissue never of itself forms a tumour, but not infrequently elastic fibres are found in connective-tissue growths. Two varieties of Fibroma are recognised, the **Hard Fibroma** and the **Soft Fibroma**, but intermediate forms occur.

The **Hard Fibroma** may be taken as the type of the class. It is an exceedingly dense or compact, firm and heavy tumour. It is very tough and on section resembles tendon. The cut surface has a brilliant white glistening appearance, and on close inspection shows a characteristic pattern, resulting from the interlacement of its constituent fibres, some of which may present a concentric disposition. The term *Desmoid* (δέσμη—a fasciculus) is often applied to the hard fibroma.

Microscopically examined the tumour is found to be composed of closely aggregated wavy fibres, interlacing and often concentrically disposed around blood-vessels (see Fig. 106). Connective-tissue cells are relatively scanty and their nuclei appear as if compressed laterally. They usually occur in the form of elongated spindles. They may be more numerous around the blood-vessels. The blood-vessels are relatively few in number and the lymphatic spaces small and narrow.

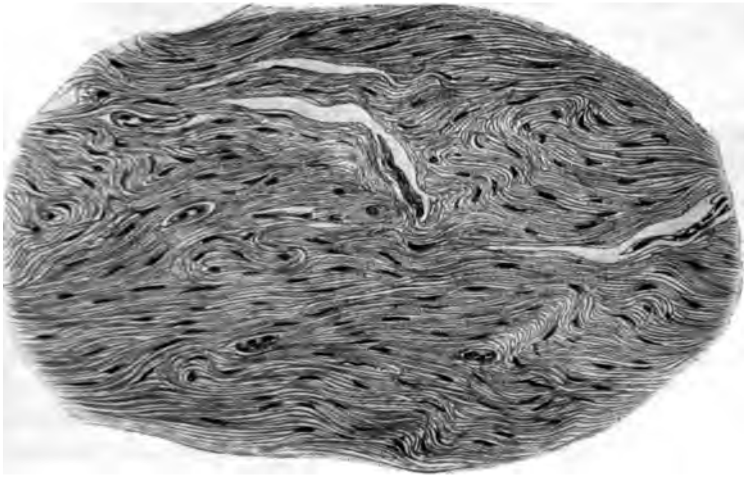

Fig. 106.—Fibroma originating in connection with fascia. × 350.

Calcification is a frequent secondary change (see Fig. 107). Not infrequently ossification occurs, especially in the case of fibromas growing from periosteum. Cartilage and gland tissue are sometimes met with in the midst of the fibres.

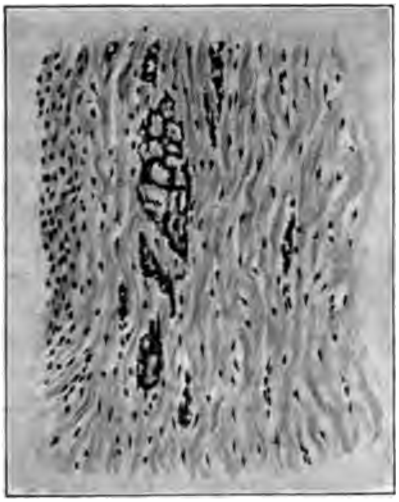

Fig. 107.—Fibroma undergoing calcification. The lime appears in the form of small dark granules. × 100.

Fibromas are frequent in connection with periosteum and bone, especially on the jaws, where they constitute one of the forms of simple epulis. Growing from the periosteum they are sometimes intimately connected with the bone, which may be as if buried in the tumour. Sometimes a fibroma originates inside a bone. Those arising from the bones of the skull, such as the basisphenoid, may give rise to extreme deformity of the face. Fibromas also occur on fascias, on sheaths of nerves, on membranes, as the dura mater, and occasionally are related to bursæ in their origin. The case from which Fig. 106 is taken originated in connection with the abdominal fascia and closely simulated clinically a floating kidney. Small glistening rounded tumours are very frequently met with in the

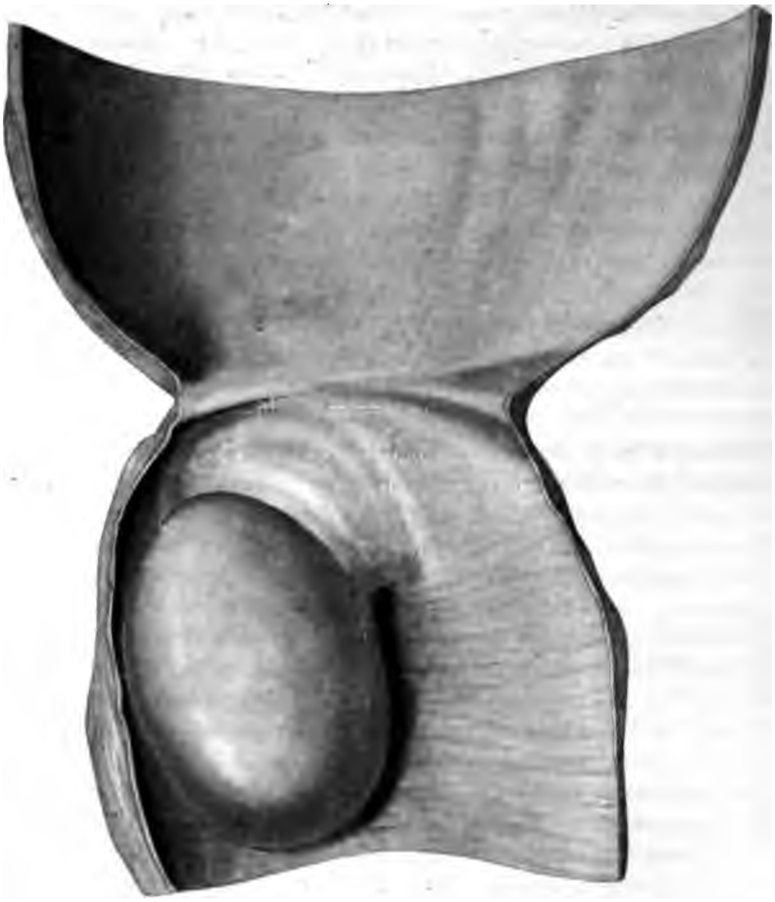

Fig. 108.—Large pedunculated fibroma of small intestine. Invagination of gut.

pyramidal portion of the kidney. They consist of a scantily nucleated fibrous tissue which not infrequently shows evidences of calcification. Remains of uriniferous tubules are seen amongst the fibres. It is probable that these small renal fibromas are of inflammatory origin. The ovary is occasionally the seat of large dense firm tumours, which by some are regarded as fibromas. Myomas occur in the same situation, and the diagnosis microscopically is often a matter of difficulty. In the mamma small fibrous tumours are common. They almost invariably contain gland elements, and are more correctly designated fibro-adenomas. We do not include here the uterine fibromas or uterine fibroids, which are really muscular tumours, and will be described as such. Fibromas are occasionally encountered in the intestine. In rare cases they may cause obstruction and invagination of the gut (see Fig. 108). The Fibrous Polypus of the rectum probably arises in most cases from a hæmorrhoid, the vessels of which have, in great part, become obliterated.

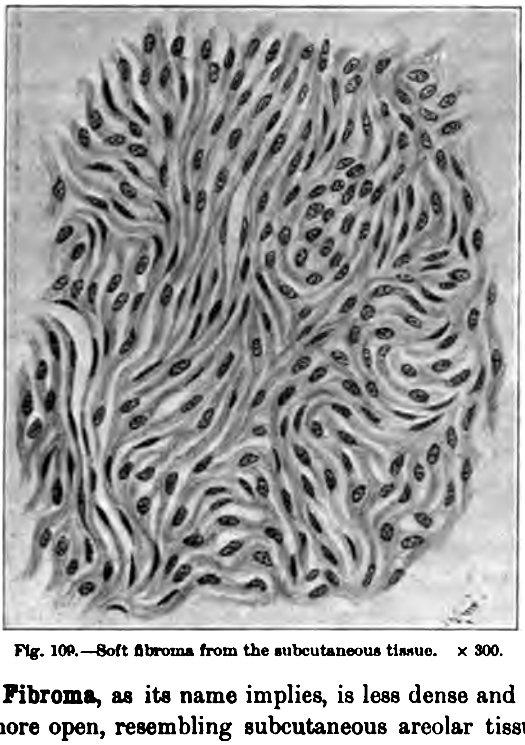

Fig. 109.—Soft fibroma from the subcutaneous tissue. × 300.

The **Soft Fibroma**, as its name implies, is less dense and tough. Its texture is more open, resembling subcutaneous areolar tissue. Microscopically examined the fibres are less compacted, the cells are more abundant, their nuclei more evident and less compressed (see Fig. 109).

Blood-vessels and lymphatic spaces are more numerous in this form. Sometimes the loose texture of the growth is rendered more obvious by the occurrence of œdema.

Soft fibromas arise generally in the subcutaneous tissue of the trunk and extremities.

As fibrous tissue is frequently the product of inflammation we may expect that the demarcation between inflammatory new-formations and fibromas is not always easy to make. Elephantiasis arabum is sometimes regarded as a simple tumour, although more properly belonging to the infective tumours. There are cases, however, of local enlargement of the skin, which have not the regular course of elephantiasis and which have more apparent analogies with tumours. To such cases Paget's name of "Cutaneous outgrowth" is applicable (Fig. 110). There are cases also, in which, with or without thickening of the cutis, there is a definite encapsuled tumour, composed of soft connective tissue, beneath the skin. Such tumours occur chiefly in the external organs of generation and may attain large dimensions. One observed by the author weighed fifteen pounds (see Elephantiasis, p. 210). The term **Elephantoid Hypertrophy** has been applied by Hutchinson to cases of irregular nodular enlargement of the labia, clitoris, and

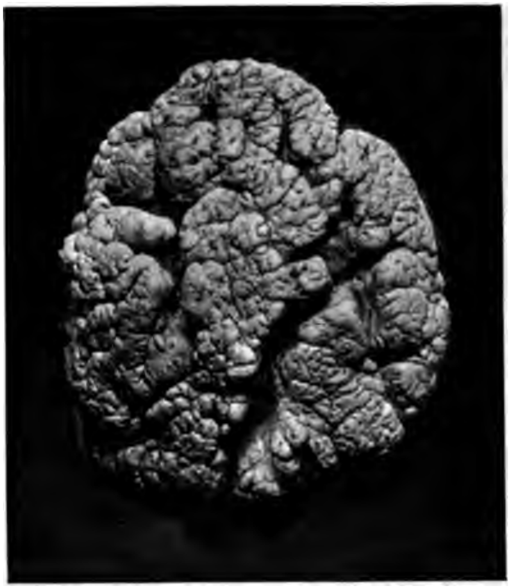

Fig. 110.—Massive cutaneous outgrowth from scalp. The mass hung loosely from the occipital region of a middle aged woman. In its size, form, and convoluted surface it resembled a brain.

mons veneris occasionally seen in women (see Fig. 111). Sometimes such enlargements become polypoid and depend from the labium by an

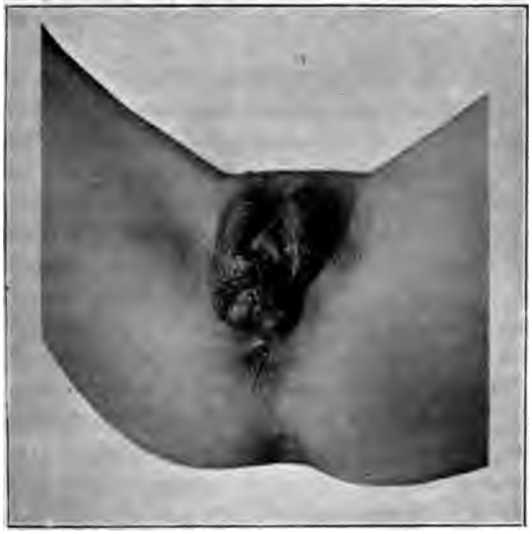

Fig. 111.—Elephantoid hypertrophy of labia, clitoris and mons veneris.

elongated stout pedicle (see Fig. 112). These tumours are often

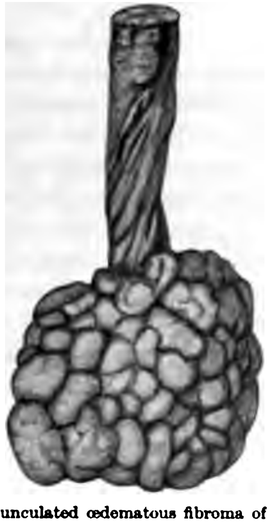

Fig. 112.—Pedunculated œdematous fibroma of labium majus.

markedly œdematous, and closely simulate myxomas in microscopic structure.

Fibroma molluscum (*Molluscum fibrosum*) or **Multiple fibro skin** are terms applied to cases in which we have multipl tumours beginning as little growths of connective tissue

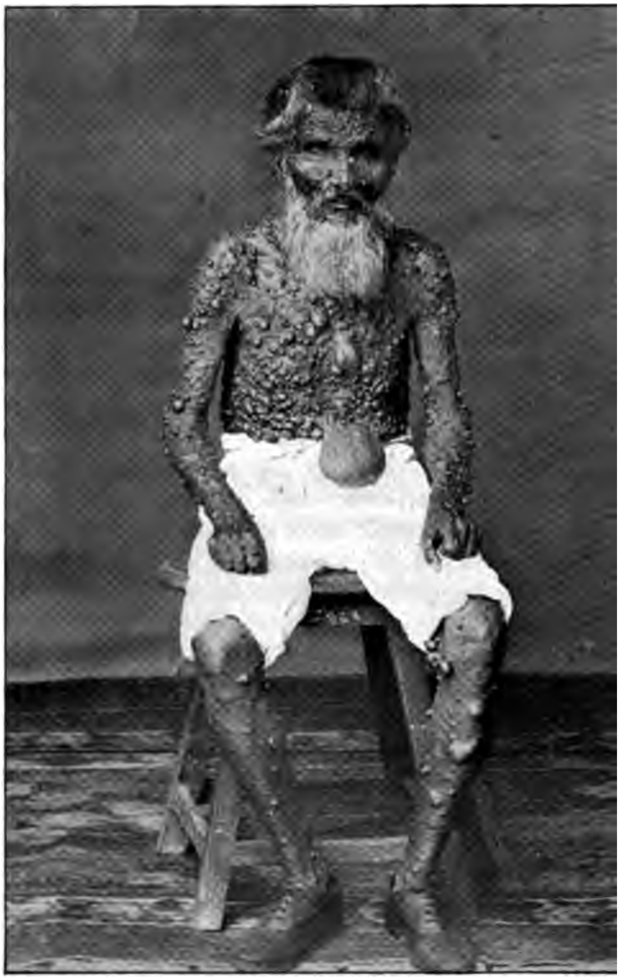

Fig. 113.—Fibroma molluscum in a man aged eighty-five years, who ha affected for forty-four years. (From a photograph lent by Dr. H. E. Jones.)

regions in the skin, and afterwards growing out and becomi lous. Thus there may be hundreds of more or less pendulou in various parts of the body (see Fig. 113). This pure molluscum must be carefully distinguished from molluscum co a totally different disease, which will be considered in the section on Diseases of the Skin.

These multiple fibromata have been made the subject of special study by Recklinghausen, who found them in two cases associated with multiple tumours of the nerves. The tumours of the nerves formed usually oval swellings in their course, and were composed of comparatively soft connective tissue in which the nerve-fibres were embedded. These tumours are frequently described under the name of Neuroma, but as they are really fibrous tissue tumours they may be regarded as false neuromata. The term **Neurofibroma** or fibroneuroma is more correctly applied. In Recklinghausen's cases the tumours of the skin were also found in their origin to be connected with nerve-stems, growing from the nerve sheath, although in growing they frequently involved the sheaths of neighbouring canals, such as blood-vessels and sweat-glands. The tumours of the nerves have frequently a plexiform character, being formed by enlargement of the sheaths of a plexus of nerves. A similar character is sometimes presented by the cutaneous tumours, and may assist in their diagnosis. Whether Recklinghausen's view applies generally to the multiple fibroma of the skin or not, remains to be determined. It is confirmed by Kriege and Westphalen, while its universal applicability is questioned by Philippson.

The **Mucous polypus** is a structure which lies on the borderland between inflammatory hypertrophy and true tumour formation. It is included by some amongst the soft fibromas. It consists of mucous membrane in which there is frequently a considerable new-formation of gland-tissue, so that in some cases the term **Adenoma** is warranted. The lesions are usually small in size, and are met with chiefly in the nares, in the uterus and in the large intestine (see Special part of work).

2.—THE LIPOMA OR FATTY TUMOUR.

This form of tumour consists of adipose tissue exactly like that of the body, as for instance the subcutaneous adipose tissue (see Fig. 114). Adipose tissue contains bands of fibrous connective tissue which carry the vessels and nerves, and so do lipomas, but in different tumours this is variously abundant. If there is little connective tissue the tumour is soft, and may even feel fluctuant. If there is much it is hard, and we may have an approach to the fibrous tumour, the **fibro-lipoma**. Further, the connective tissue may assume, in parts at least, the fœtal type (myxo-lipoma). The fibrous character may be increased by irritation, as where a tumour is exposed to friction, producing a kind of indurative inflammation in the tumour. Calcification of the stroma and softening, with the formation of cyst-like cavities, may considerably alter the aspect of the tumour.

Lipomas form greyish-yellow masses, usually distinctly lobed. The lobing often assumes the form of digitate processes at the margin of the growth. They are mostly surrounded by a distinct capsule, but sometimes they are continuous with the surrounding fat. Thus the fat around the mamma or the kidney may undergo such an enlargement as to warrant the name of tumour (*Lipoma capsulare*). Billroth mentions a lipoma which had grown in between the muscles of the thigh in such a way that it could not be removed completely. Lipomas which are not definitely circumscribed may be called **Diffuse lipomas.** The massive fatty tumours sometimes seen in the neck are instances of diffuse lipomas.

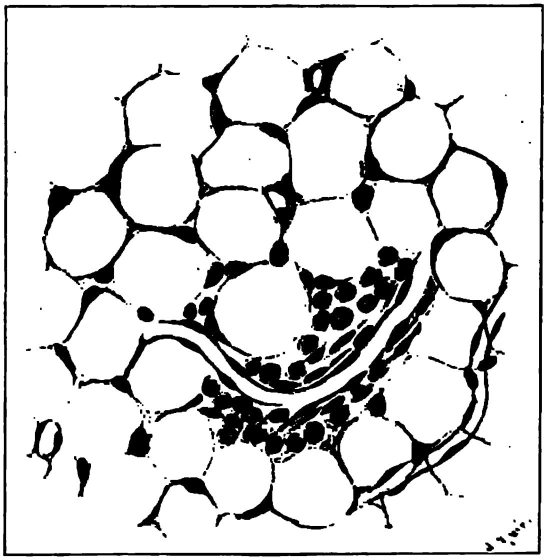

Fig. 114.—Lipoma of buttock. × 200.

Fatty tumours are for the most part single, but in some cases they are **multiple.** When multiple they do not grow simultaneously, and may appear in succession for months or years. They are occasionally **symmetrical.** Their size is very variable, ranging from minute tumours just visible to the naked eye to enormous masses fifty to a hundred pounds or even more in weight. **Sessile** and **pedunculated** and **pendulous** forms are met with. The latter as a rule do not attain very large dimensions, but they may, by their weight, gradually slide downwards, leaving their old attachments and acquiring new ones. There is apt to be ulceration of the surface of such tumours and even hæmorrhage.

Lipomas are of common occurrence. They are sometimes congenital, especially in connection with spina bifida. In *spina bifida occulta* a considerable mass of adipose tissue is often found in the lumbo-sacral region overlying and concealing the spinal defect (see Spina bifida). Their most frequent seat is under the skin, especially of the trunk and trunk-ends of the extremities (*Subcutaneous Lipoma*). They are less common under mucous membranes (*Submucous Lipoma*), as that of the stomach (Fig. 115), intestine (Fig. 116), larynx, etc. In the intestine they may become polypoid (Fig. 116). They are occasionally met with in connection with serous and synovial membranes, in the appendices epiploicæ of the intestines, or the synovial fringes (*Subserous* and *Subsynovial Lipoma*). In the appendices epiploicæ the neck of the polypoid mass often becomes twisted by axial rotation (Fig. 117). The connection may be severed and the tumour become a **loose body** in the peritoneal cavity, subsequently it may become adherent in various situations. The synovial fringes of the larger joints not infrequently become enlarged in number and size and project into the joint cavity in the form of numerous small fringes or frond-like processes (*Lipoma arborescens*). This condition is not uncommon in chronic rheumatoid arthritis, where sometimes some of the ingrowths are found lying free in the articular cavity. Lipomas are rarely heterologous, occurring where fat is not present normally, as in the substance of the kidneys, brain, etc. They are of rare occurrence on the surface of bones, constituting the *Parosteal lipoma*. The parosteal lipoma is usually congenital, and striped muscle is often found amongst

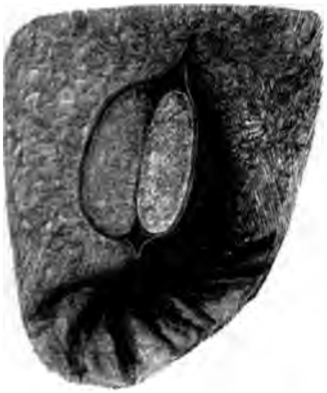

Fig. 115.—Lipoma in the wall of the stomach. It was the size of a hazel-nut, situated near the pylorus in the submucous tissue. Natural size. (VIRCHOW.)

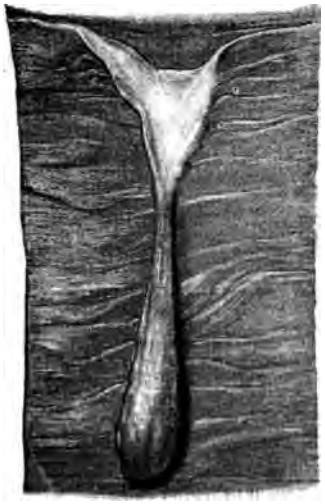

Fig. 116.—Pedunculated submucous lipoma of colon. Half natural size.

the adipose tissue. The author met with a case in which an elongated piece of fat lay on the upper surface of the corpus callosum.

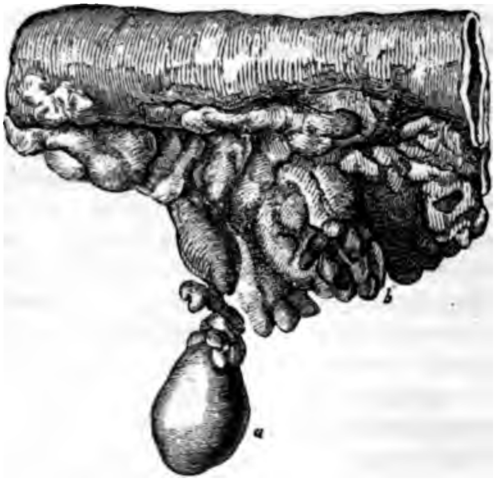

Fig. 117.—Pendulous lipoma of appendix epiploica of colon. A pedunculated tumour (*a*) projects from the general mass of subserous adipose tissue (*b*). It is twisted twice on its axis, and the peduncle is very thin. (VIRCHOW.)

Lipoma nasi is a misleading term sometimes employed to designate the hypertrophic form of acne rosacea. It is in no sense a fatty tumour. **Adiposis dolorosa** is a rare condition, which might be confounded with diffuse lipoma. It is referred to under Diseases of the Nervous System.

3.—THE MYXOMA OR MUCOUS-TISSUE TUMOUR.

This form of tumour is composed of mucous tissue, and as this is not one of the physiological tissues of the adult, it will be proper to refer more specially to its characters. The blood-vessels of the umbilical cord are padded and protected from pressure by a gelatinous substance called Wharton's jelly. Under the microscope, this consists of variously shaped cells separated by a clear transparent intercellular substance. The intercellular substance is of gelatinous consistence, and owes this character to the fact that it consists of a watery solution of mucin.

Mucin is nearly allied to albumen, but when present in even small quantity in a solution, it gives the latter a sticky gelatinous character. Its chemical reactions also differ from those of albumen, in respect that, though like it precipitated by alcohol, the precipitate is redissolved by water. Also, acetic acid and other organic acids precipitate mucin, but not usually albumen. The precipitate of mucin by alcohol or acetic acid is more membranous than that of albumen. The reaction ith acetic acid can be readily brought out in Wharton's jelly or in a myxoma, a icroscopic section showing, on adding acetic acid, a reticulated precipitate. These reactions can also be studied in the mucus from any mucous membrane, or in the bile, in which mucin is normally one of the dissolved constituents. By treatment with special staining reagents which have an affinity for mucin (thionin, toluidene blue) a mucin reaction may be obtained.

Besides the umbilical cord, mucous tissue is present in the villi of the chorion of the fœtus, the villi consisting of a double layer of epithelium with mucous tissue internally. In the fœtus, it is also present in early stages in the subcutaneous tissue, where it has the place of the subcutaneous adipose tissue, being, in fact, related to fat very much as the temporary cartilage is to bone. Some remains of this tissue are met with in the adult. Thus, the vitreous humour of the eye is really composed of soft mucous tissue, and traces of it have been found in places where normally adipose tissue exists, as under the pericardium, at the hilus of the kidney, subcutaneously, and in the medulla of bone. It is said to occur also around the acini and ducts of the mamma. It appears that in these positions there is sometimes a partial recurrence to the fœtal condition. The special connective tissue of the brain, the neuroglia, is allied to mucous tissue, and seems to present a proneness to return to that form.

The **hydatid mole**, which arises by a great new-formation of mucous tissue in the villi of the chorion (see Fig. 118), is regarded by some as a form of myxoma. (See further on in Section on Generative Organs.)

Mucous-tissue tumours are met with principally in the subcutaneous tissue, where they may be regarded as probably due to a piece of embryonic tissue left over when the mucous tissue was converted into adipose tissue. In this respect they resemble the chondromas of bone. They form rounded or oval tumours, often lobulated and encapsuled, generally soft, and sometimes almost fluctuant in consistence and hyaline in appearance. The glistening translucent appearance is very characteristic. On section a viscid yellowish fluid drains away. These tumours are sometimes described as soft fibromas or fibro-cellular tumours. Examined under the microscope we have a very translucent tissue—so translucent that in unstained sections it may escape observation—in the midst of which are irregularly shaped cells, with long, often anastomosing, processes (Fig. 119). The cells are described as angular or stellate, but they may be fusiform. The tissue is intersected by more or less frequent bands of connective tissue. The number of cells varies considerably in different cases, and even in different parts of the same tumour.

Myxomas are also of somewhat frequent occurrence in the brain as compared with other tumours of this organ. They arise in connection with the soft membranes of the brain and spinal cord, or in the ventricles, or in the substance of the brain. They sometimes grow to considerable size, and are liable by softening to take the form of cysts filled with a mucous fluid. They are also met with on peripheral nerves. They occur in the mamma (see Fig. 119), where not infrequently they appear to have the character of a diffuse formation of mucous tissue between the glandular acini, so that the gland as a whole is converted into a tumour. In the salivary glands they also occur, but are usually of mixed structure, being partly formed of other kinds of tissue. Certain forms of nasal and aural polypi have the structure of a myxoma

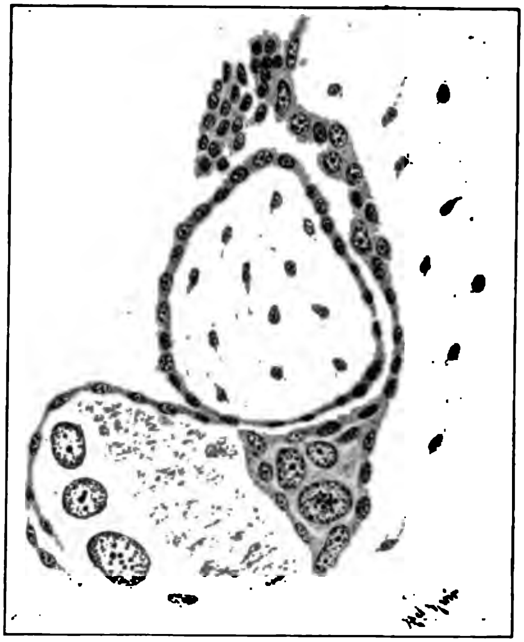

Fig. 118. Hydatid mole. × 200.

The simple pure hyaline myxoma is not very common, as the tissue is apt to be mixed with other forms. From the relation of mucous and adipose tissues it is not remarkable that a partial conversion of a lipoma into a myxoma, or *vice versa*, is met with. There is also not infrequently a mixture with fibrous, cartilaginous, or glandular tissue. Then, also, the myxomas vary very greatly in the proportion of cells, the very cellular ones being called medullary myxomas, and frequently graduating into sarcomas. In fact, with pathologists who take the embryonic nature of the tissue as the criterion of sarcomas, the fact that mucous tissue is the embryonic precursor of adipose tissue induces them to class this form of tumour among the sarcomas. Consistently with these facts there are some myxomas which show malignant characters, either local or general. In a case recorded by Virchow there were tumours on the nerves and in the dura mater of the cord and brain.

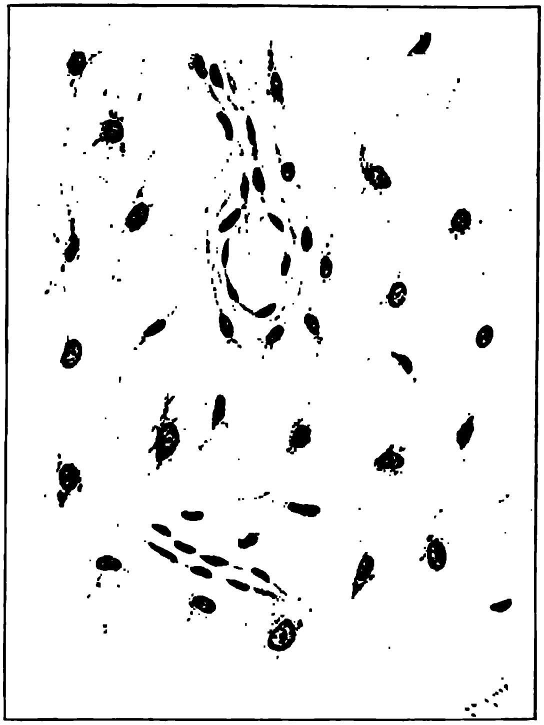

Fig. 119.—Myxoma of mamma. × 200.

4.—THE CHONDROMA OR CARTILAGINOUS TUMOUR.

This tumour is composed of cartilaginous tissue. The cartilage may be hyaline (see Fig. 120) or fibrous, generally the latter, and the matrix is not infrequently rather soft. The tumour is also intersected with fibrous bands which carry blood-vessels that nourish the tissue. If a cartilaginous tumour grows in connection with and out from cartilage it is called an **Ecchondrosis**, but if, as in the majority of cases, it grows in connection with other tissues, it is then called an **Enchondroma.** The term chondroma of course includes both.

The ecchondroses are usually small unimportant outgrowths chiefly of the cartilages of the septum nasi, larynx, trachea and ribs.

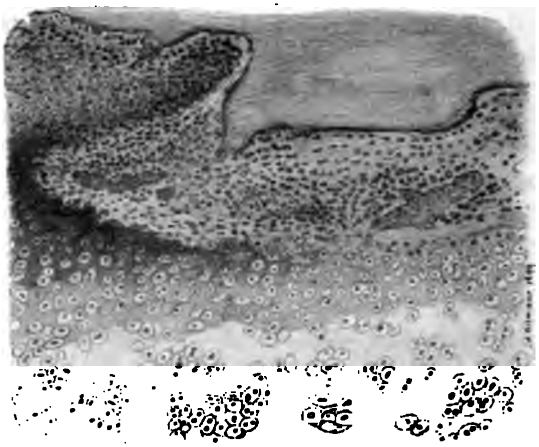

Fig. 120.--Chondroma of bone. In the lower part the matrix is hyaline; in the upper part calcification and ossification have occurred. × 80.

Virchow has described an interesting form of so-called ecchondrosis at the basilar portion of the occipital and sphenoid bones. The basilar parts of these bones are formed from cartilage, and in adult life they are united, forming a single bone (os tribasilare). The junction takes place irregularly by a kind of toothed union. In this process a little bit of cartilage may be omitted, and this sometimes develops into a little tumour just under the basilar artery to which it may be adherent. It will be seen that we have here an actual instance of a little piece of embryonic tissue left over to develop afterwards into a tumour. This little tumour sometimes undergoes a remarkable change; the cells swell up and become like those of the chorda dorsalis, but in other cases it ossifies.

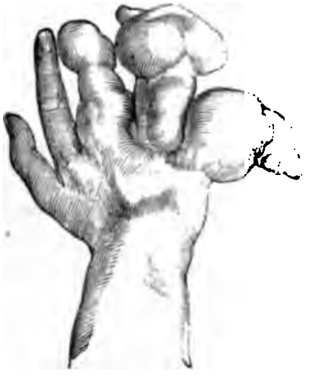

Fig. 121.—Multiple central enchondromata of fingers. (CORNIL and RANVIER.)

The cartilaginous loose bodies in joints are sometimes regarded as originally outgrowths from the cartilages or synovial fringes which have been broken off and grown after their separation.

Enchondromas are mostly met with **in connection with Bones.** As bones are developed out of cartilage for the most part, it may be *supposed* that small portions of the embryonic cartilage are left over and develop into tumours afterwards. The enchondromas of bone may be divided into central and peripheral, according as they originate in the medulla or at the surface. The **central enchondromas** are met with chiefly in early life, and may be congenital. They occur especially in the fingers and toes, which may be the seat of multiple tumours as in Fig. 121. These tumours begin inside the phalanges or metacarpal bones, or, less frequently, the analogous bones of the foot. Growing inside the bones they may be for a time unperceived, but afterwards they swell up the bones and may even burst through the external shell. These tumours often show a local malignancy, growing by the formation of new nodules in the tissue around. The **peripheral chondromas** are met with most frequently on the femur and pelvis, and most rarely on the bones of the face and skull.

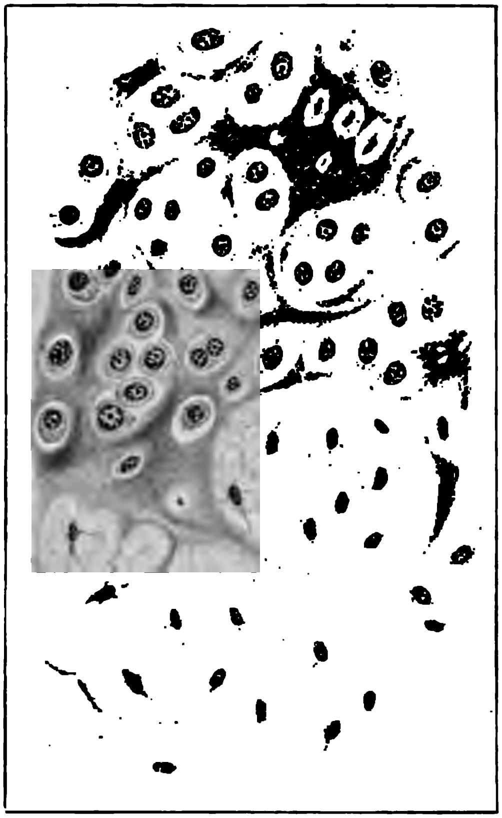

Fig. 122.—Chondroma with myxomatous degeneration. The matrix of the cartilage is calcified at upper part of figure. × 200.

In soft parts chondromas are found occasionally, but are commonly mixed with fibrous, mucous, glandular, sarcomatous, or cancerous elements. They are particularly frequent in glands, as the testes, ovaries, and salivary glands. In these situations they are occasionally found to follow chronic irritations.

In their form chondromas are generally rounded tumours and distinctly encapsuled, but if large they are lobulated.

It has already been said that the chondromas are often mixed with other tissue; to this must be added that secondary changes are not infrequent. They sometimes soften, a condition frequently due to partial transformation into mucous tissue (see Fig. 122). This is particularly the case with the glandular enchondromas. On the other hand, those of bone are liable to undergo calcification and ossification (Fig. 120).

Lastly, chondromas are liable, as has already been said, to show a certain malignancy, forming secondary tumours, especially in the lungs. This is connected with the frequently mixed character of these tumours and their association especially with sarcomas and cancers.

5.—THE OSTEOMA OR BONY TUMOUR.

In this class are included tumours composed of bone, not mere new-formations due to inflammation or tumours in which bone exists as a subordinate element with other tissue.

The large majority of bony tumours grow from bone, and are hence called **Exostoses.** In regard to their structure, some are like spongy bone with the interstices filled with ordinary bone-marrow, and some are composed of dense bone such as form the shaft of a long bone, and are called ivory exostoses.

There are also tumours which originate in the teeth. When these are composed of cement they are properly called denta **osteomas,** but when formed o dentine, **odontomas.** The latte

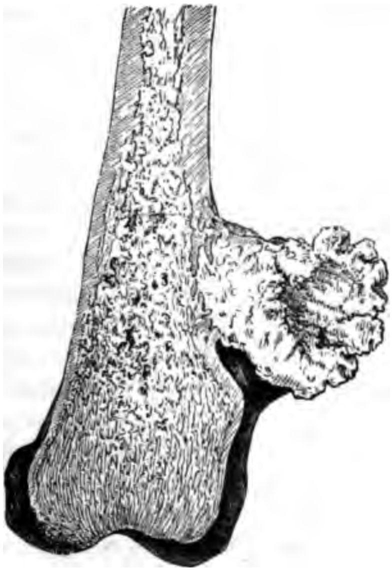

Fig. 123.—Cartilaginous spongy exostosis of femur. (VIRCHOW.)

term, however, is often applied to either form. The tumour may be little more than a local enlargement of the fang, rendering extraction difficult, or there may be a distinct tumour, growing sometimes to the size of a walnut. In the latter case it is usually a true odontoma, composed of a structure like dentine.

Of the proper exostoses several forms are distinguished.

(1) The **Spongy exostosis,** or the **Exostosis cartilaginea** (Fig. 123). These tumours occur mostly at the epiphyses of the long bones, and are derived primarily from the epiphysial cartilage. In rare cases they may be multiple (Fig. 124). A rather favourite seat is the dorsal aspect of the last phalanx of the great toe, where they project beneath the nail and produce great pain and discomfort (*sub-ungual exostosis*). They grow during childhood, and, just as the cartilage from which they originate ossifies, so do they, and the bony tumour formed is directly continuous with the bone beneath. The tumour begins as a small outgrowth, and so the first bone formed is a narrow piece. The cartilage, as it goes on growing, enlarges in every direction, and so overhangs its base, the tumour thus becoming larger as it grows outwards, and consequently pedunculated. The tumour consists of spongy bone with a layer of cartilage on its surface (see Fig. 125). It is enough to snip through the base in order to remove the tumour.

(2) The **Ivory exostosis** is mostly met with on the bones of the head,

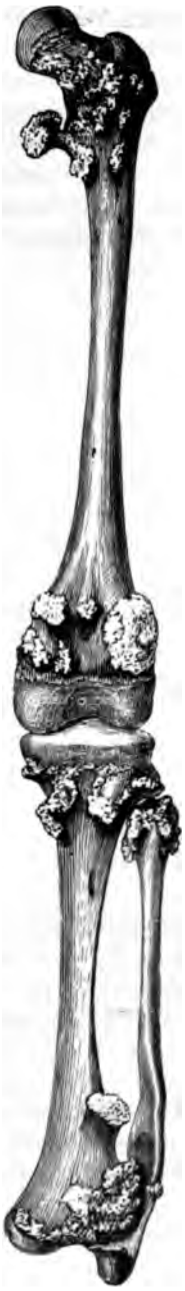

Fig. 124.—Multiple exostoses of femur, tibia, and fibula. These are grouped towards the ends of the diaphyses. At its lower end the fibula is flattened by the exostoses growing out from the tibia. From a boy ten years of age. One third the natural size. (VIRCHOW.)

but also on the pelvis, scapula, great toe, etc. The tumours a usually rounded in form, and may be tuberculated on the surface.

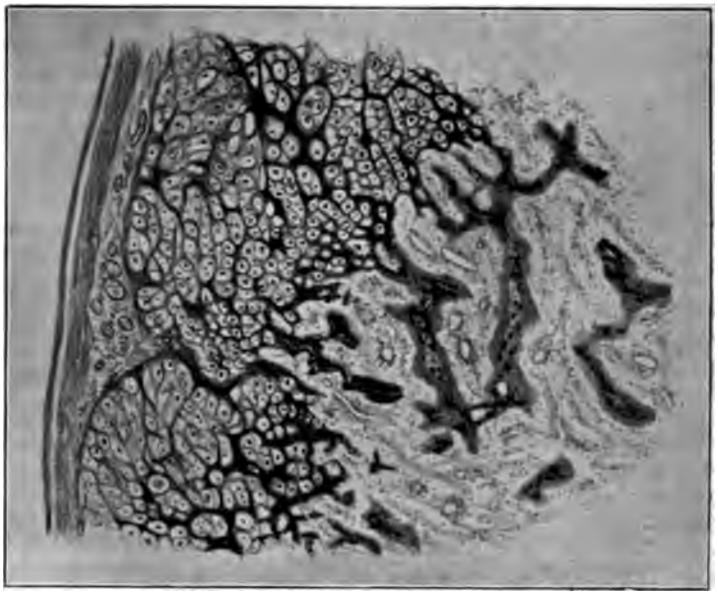

Fig. 125.—Cartilaginous exostosis. A thick layer of cartilage surmounted by fibrous tissue is shown in the left half of the illustration. The right half is composed of cancellated bone. × 40.

their favourite seat on the head they may grow from the external tal and project externally, from the internal ta and project internally in Fig. 126), in which c they may produce irri tion of the brain substa beneath.

It sometimes happ that an ivory exost grows from correspond parts of both external a internal tables. Th tumours are sometir multiple (as in Fig. 12

(3) **Hyperostosis** a **Periostosis** are nar applied to growths of bone which are not properly tumours. Tl

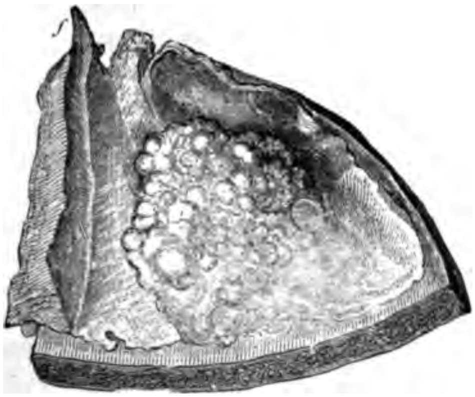

Fig. 126.—Internal ivory exostosis of the frontal bone. The surface is tuberculated, and the tumour has a narrow base. It was situated to the left of the falx (*f*). Natural size. (VIRCHOW.)

are localized thickenings of bones or portions of bones. This growth of particular parts of the bones of the head may become so independent in its manner that the characters of a tumour are simulated. The condition known as **Leontiasis ossea** is an instance of this (see under **Diseases** of Bone).

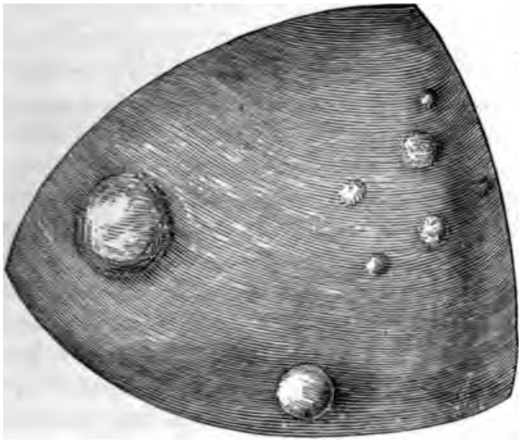

Fig. 127.—Multiple exostoses of the frontal bone. Natural size. (Virchow.)

Osteomas of other parts than bones are rather rare. It is remarkable, however, that bony masses occur sometimes in the central nervous system. They are met with in the arachnoid, where they used to be regarded as evidences of chronic irritation. They can hardly be regarded as tumours. Actual tumours occur in the dura mater, and even in the brain substance. They are also met with in the eyeball, in the lungs, and, as little bony granules, in the skin.

6.—THE MYOMA OR MUSCULAR-TISSUE TUMOUR.

These are tumours in which muscular tissue is the essential constituent, but just as all muscles have supporting connective tissue so have these, some more, some less. As there are two kinds of muscle, so are there two forms of muscular tumour, those composed of striated, and of smooth muscle respectively.

The **Myoma strio-cellulare** or **Rhabdomyoma** is very rare. Tumours of this structure are probably always congenital. They have been seen in the heart, kidneys, ovaries, and testicles. The tumour is not usually composed of ordinary striated muscle, but the muscular fibre is embryonic in character, consisting of spindle-shaped cells, which are transversely striated. Tumours of this kind have strong analogies with sarcomas, and are sometimes designated myo-sarcomas. Besides this, similar rudimentary muscle is occasionally met with in other forms of sarcoma, in cystic tumours of the ovary and testicle, and in teratomas.

The **Myoma lævi-cellulare** or **Leiomyoma** is an exceedingly common form of tumour, and is met with in almost every part where smooth muscle exists normally. According to the amount and density of the interstitial connective tissue is the consistence of the myoma—it may be very dense, and warrant the name Fibro-myoma, or it may be so hard as to resemble cartilage.

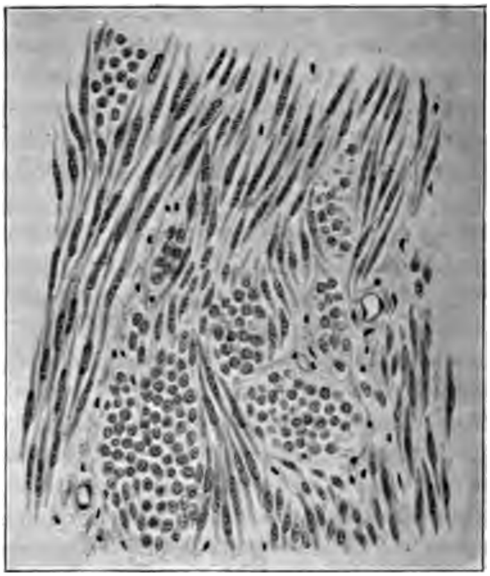

Fig. 128. Myoma uteri. Closely aggregated fibres with rod-shaped nuclei are seen on longitudinal and transverse section. A small amount of fibrous tissue, with blood-vessels, separates the bundles. × 200.

Myomas are often described as fibrous tumours, and in appearance they justify this designation. To the naked eye they appear fibrous on section, and even under the microscope they show a fibrous appearance, but on adding acetic acid to a microscopic section, or on staining with carmine or other reagent, the fibres are seen to be much more abundantly nucleated than ordinary connective tissue. In fact, rod-shaped nuclei (not spindles as in connective tissue) are so closely set as at once to suggest a cellular tissue (see Fig. 128). It may here be remarked that in the unimpregnated uterus there is the same difficulty in distinguishing the individual spindle-cells. In both cases, however, the cells may be isolated by macerating the tissue for twenty-four hours in a 20 per cent. solution of nitric acid, or for twenty to thirty minutes in a 34 per cent. solution of caustic potash. This softens the tissue, and separates the cells, which are recognized as spindles.

Myomas always arise where muscle already exists, and as smooth muscle is most frequent in the walls of mucous canals and cavities, it is there that they usually originate. The tumour may be continuous with the muscular wall, forming an outgrowth from it, or it may be distinctly isolated and encapsuled. It may remain in the substance of the muscular wall (*intraparietal* or *intramural*), or it may slip inwards so as to bulge under the mucous membrane (*submucous*), or it may pass outwards and present under the serous coat (*subserous*). In the two latter cases the tumours often become polypoid.

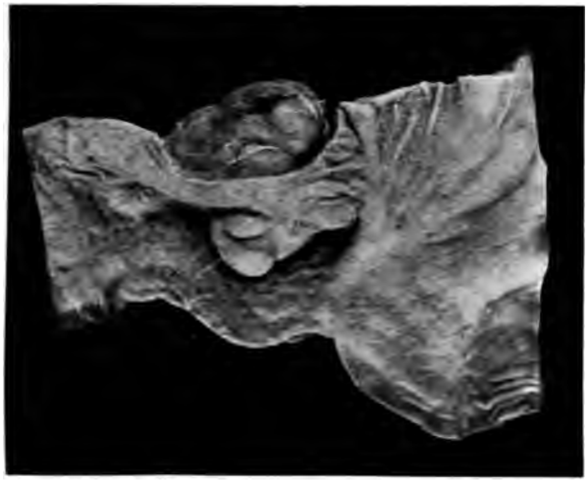

Fig. 129.—Myoma of duodenum. The tumour projects both externally and internally.

By far the most frequent seat of the myoma is the **female organs of generation**, generally the uterus, but also the ligaments and ovaries. The so-called uterine fibroids are myomas, and the most important of these are the submucous which so frequently become polypoid, and give rise to hæmorrhage, sloughing, etc. The gland-spaces and cysts sometimes found in uterine myomas are regarded by Recklinghausen and others as remains of the Wolffian body.

In the **prostate** the hypertrophy frequently met with in old men is really from the formation of muscular tissue, and the third lobe which forms a bulging projection at the neck of the bladder is an outgrowth from the muscle of the prostate (see **Prostate**). Sometimes there are even isolated muscular tumours in the midst of the prostate. This form of tumour is to be distinguished from the glandular tumour, which is a much rarer form of hypertrophy and occurs mostly in young men. Myomas of the **œsophagus** are occasionally met with, and are usually submucous. In the **stomach** submucous and subserous myomas are not uncommon. Multiple tumours of small size are often met with in the vicinity of the œsophageal opening. In the **intestine** they are occasionally met with (see Figs. 129, 130). They may project from both serous and mucous surfaces, and may encroach on the lumen of the gut (see Fig. 129). They have also been seen in the urinary bladder.

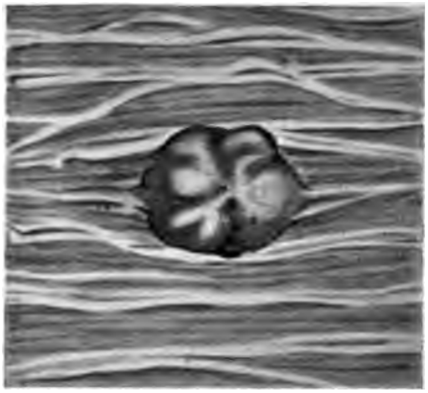

Fig. 130.—Small myoma of ileum. The tumour projected both externally and internally.

Myomas of the **skin** and **subcutaneous tissue** occupy a peculiar position. We have first obvious myomas growing usually in parts rich in muscle, such as the nipple and scrotum. We have further multiple myomas of the skin, forming well-defined tumours which are sometimes very painful. Lastly, there is the so-called Tubercula dolorosa, which, at least in most cases, is a myoma, if not in all. It merits a special description.

The **painful subcutaneous tubercle, Tubercula dolorosa,** or Wood's tumour, is, in most cases at least, a subcutaneous myoma. It occurs in the form of a small round tumour under the skin (see Fig. 131), and is commonly the seat of intense pain. The pain indicates some connection with the nerves, but there is no demonstrable nerve fibre to be traced into the tumour. According to Virchow there are tumours of various structure in this category, myomas, angiomas, and neuromas. Axmann has suggested, with some probability, that the little tumour may in some cases be an enlarged Pacinian body, and recently Hoggan has described one which he believes to be an adenoma of the sweat-glands, but which Virchow regarded as an angioma. In all the cases which we have examined the tumours consisted of a dense interlacing network of fibres, very suggestive of a myoma. On macerating portions in nitric acid the tissue broke up into large spindle cells. These tumours were probably myomas of the skin. The view that these tumours are myomas is confirmed, not only by further observations of the author, but also by those of Malherbe, who, in five consecutive cases, found the structure to be uniformly that of the myoma. He believes that whilst other tumours of the skin may be painful, the myoma has a place and symptomatology of its own, and constitutes the true Tubercula dolorosa.

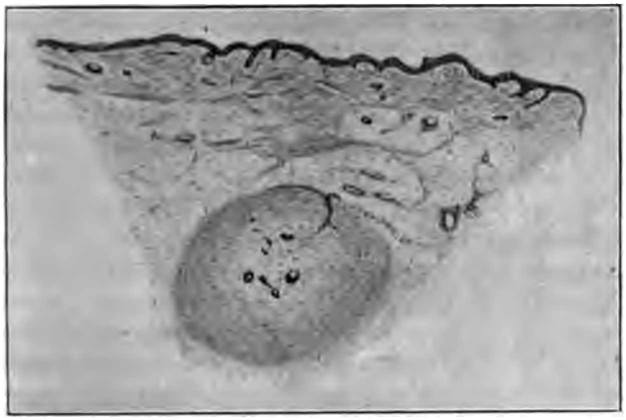

Fig. 131.—Tubercula dolorosa. The epidermis and cutis are seen in section. The round tumour is situated in the subcutaneous fat. × 8.

The muscular tissue of the tumour probably arises from the arrectores pilorum of the skin. The tumour tends like other myomas to slip from its original position and to pass into the loose subcutaneous tissue. It may be this shifting of position, by causing dragging on the sensitive nerve twigs of the skin, which leads to the paroxysms of pain.

The myoma is of **slow growth.** It may go on as long as thirty or forty years, and may reach a very great weight—as much as 60 lbs. It is nearly always an innocent tumour, but a case is recorded by Brodowski in which a large myoma of the stomach gave rise to secondary tumours in the liver. In all probability, in this case, the primary tumour was a myosarcoma. Retrograde changes may occur, such as fatty degeneration, resulting in shrinking or the formation of cysts. If induration occurs from formation of hard connective tissue, this may calcify, leaving the muscular tissue in the spaces between the calcified trabeculæ. In some cases, from derangements of the circulation in large tumours, we may have an actual necrosis of a portion of the muscular substance, resulting sometimes in absorption and the formation of a cyst. In other cases, the dead structures become calcified, as in Fig. 132, where muscular elements, connective tissue, and walls of blood-vessels were all found impregnated with lime. As the myomas so readily become polypoid, they are liable to be insufficiently nourished, as the neck gets thinner; sloughing may even occur, especially if they present on a mucous surface, and become exposed to injury. Such tumours are also liable to bleed, especially as the vessels in them sometimes undergo great dilatation.

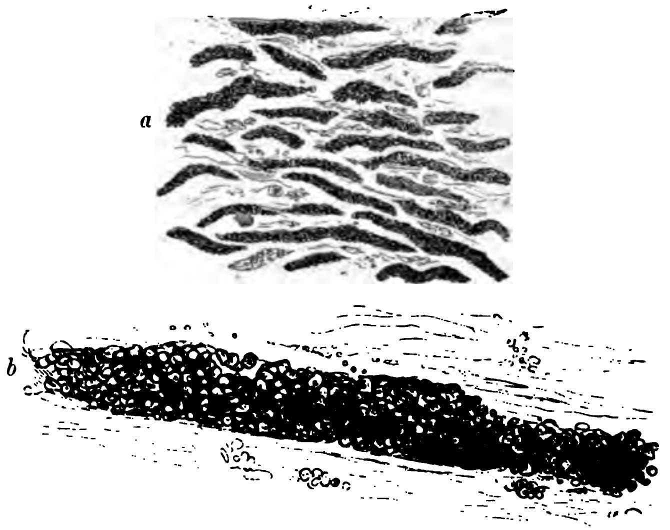

Fig. 132.—From a myoma, a portion of which has become calcified. *a*, muscular fibre-cells impregnated with lime salts; *b*, a blood-vessel with wall incrusted. ×350.

7.—THE NEUROMA OR NERVOUS-TISSUE TUMOUR.

A neuroma is properly a tumour composed of nerve tissue. As there are two kinds of nerve tissue so we may distinguish a ganglionic and a fibrous neuroma. The ganglionic neuroma is an exceedingly rare tumour, and some of the recorded cases would bear another interpretation. There are some cases of small tumours projecting from the cortex of the brain which may be named ganglionic neuromas, and the swellings sometimes met with in connection with sympathetic plexuses may also be placed in this category.

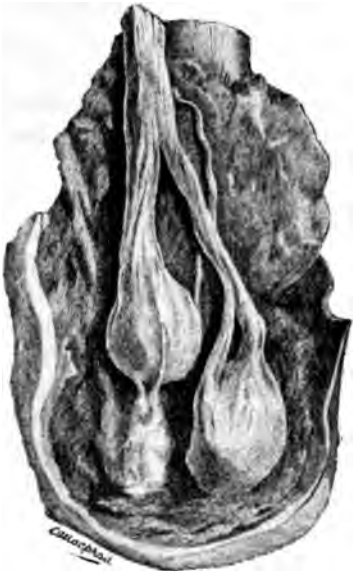

Fig. 133.—Amputation neuromata in a stump. The internal and external popliteal nerves are involved. The amputation was ten years before.

All tumours of nerve stems are usually designated neuromas, but as such tumours may really be composed of fatty, mucous, or fibrous tissue, it has become customary to distinguish those which actually contain new-formed nerve fibres as true neuromas, and the others as false neuromas.

The **true neuroma** is composed of nerve fibres, which may be either medullated (*Myelinic neuroma*), as in the ordinary cerebro-spinal nerve, or non-medullated (*Amylenic neuroma*). One of the most striking forms is the so-called **Amputation neuroma** (Fig. 133), which is a very frequent if not constant occurrence in stumps. The tumours are usually multiple, and form bunches of little knobs, which have a hard consistence, and to the naked eye look fibrous. Under the microscope medullated nerve fibres are found running in bundles, but there are also many fine fibres which are probably non-medullated nerve fibres. It is in this case as if the cut end of the nerve had made an attempt at regeneration of the lost portion. Allied to this form is the **traumatic neuroma**, occurring as the result of an injury in the course of a nerve.

But neuromas occur in the course of nerves spontaneously, and they are often multiple, forming oval swellings, hard and fibrous in appearance. They contain much fibrous tissue, in the midst of which there are medullated nerve fibres (see Figs. 134, 135) recognizable in the fresh state by the double contour, especially when the connective tissue has been rendered transparent by acetic acid or liquid potassæ. But usually in addition to these medullated fibres, there are fine nucleated fibres, which Virchow regards as non-medullated nerve fibres. In some neuromas these are very abundant. An interesting but rare form is the **Plexiform neuroma**.

In it the nerves in an area of the skin become enlarged, so that part to the touch feels like a congeries of worms The enla

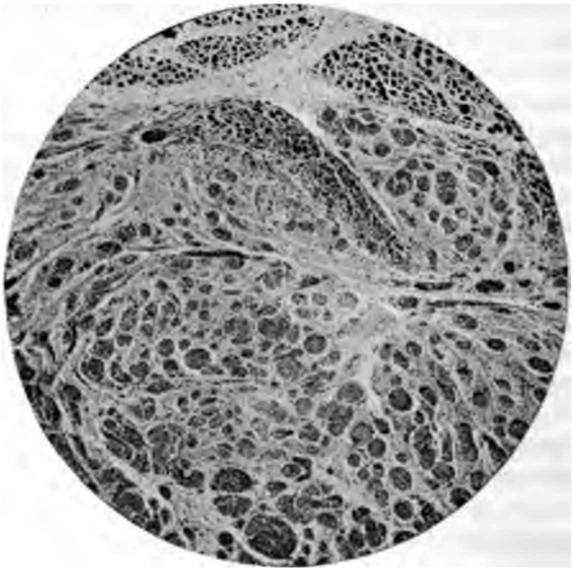

Fig. 134.—Amputation neuroma. Transverse section. In the upper part of the illustration muscular tissue is shown. × 35.

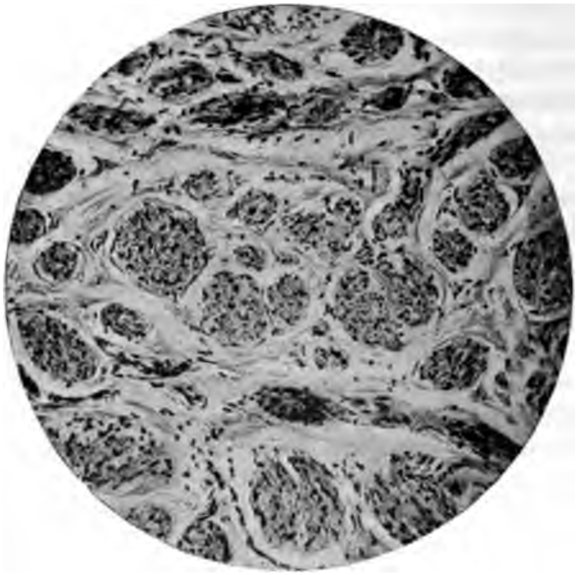

Fig. 135.—Amputation neuroma. The same as Fig. 134 under higher magnification. × 130.

nerves vary from the size of a crow-quill to that of the thumb. The tumours are mostly congenital.

There is no doubt that most tumours of nerves are really false neuromas. This applies, as we have seen at p. 287, even to the multiple tumours which have been usually regarded as the typical neuromas. It applies also, at least in part, to the amputation neuromas. It is obvious that as a nerve stem is composed of connective tissue and nerve fibres, it must be often very difficult to determine whether there has been new-formation of nerve fibres or not. It seems questionable whether it is worth while, for the sake of consistency in nomenclature, to attempt to restrict the term neuroma to those actually composed of nerve tissue.

8.—THE ANGIOMA OR VASCULAR TUMOUR.

We have here a tumour composed of blood-vessels or lymphatics. The tumour varies in bulk according to the fulness of the vessels, hence some of them are occasionally designated **Erectile tumours.** The term **Nævus,** though really meaning *nativus*, or congenital mark of any kind, is almost synonymous in its use with angioma of the surface.

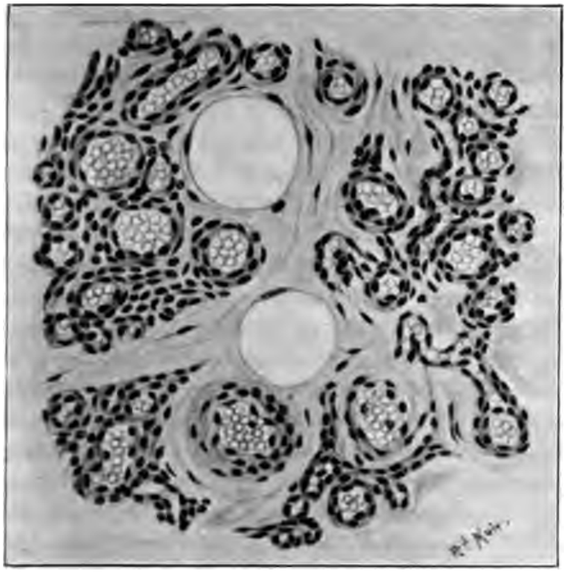

Fig. 136.—Subcutaneous nævus. A congeries of small tortuous vessels filled with blood is shown in the midst of fibrous tissue. × 200.

The commonest form is (1) the **Plexiform** or **Capillary angioma.** This includes most of the vascular nævi, and consists of capillary and intermediate vessels forming a rich plexus (see Fig. 136). It is mostly a growth of the skin, and may be very small or cover a large a forming a flat soft surface of dark or bright hue. It is nearly alw congenital, although it may increase in size after birth. Min capillary nævi are very common, and are frequently multiple. Tl capillary nævi graduate into (2) the **Venous** or **Varicose nævi,** those consisting of dilated veins (Fig. 137). They have sim situations to the capillary form and similar appearances.

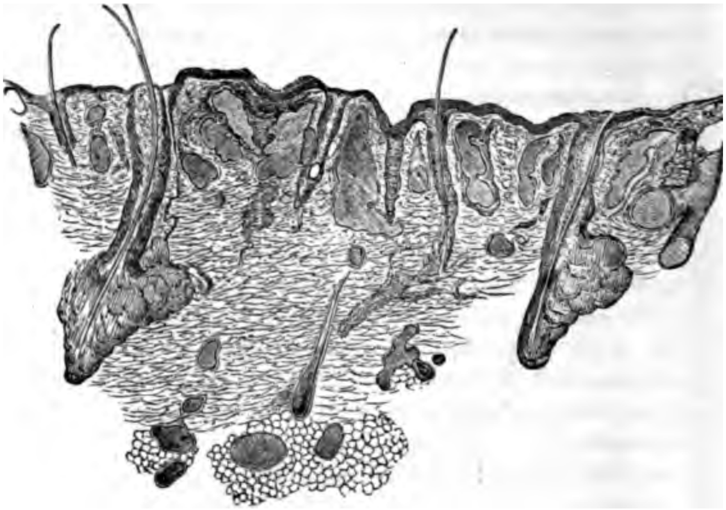

Fig. 137.—Section of skin in a case of diffuse venous nævus. The large sinuses (shaded) are seen to lie superficially between the hair-follicles and glands. (Virchow.)

(3) The **Cavernous angioma** consists of tissue like that of the cor cavernosum of the penis or clitoris, namely, a network with mes which communicate freely and are filled with blood. When em they are seen to be composed of a pale tissue, in its texture resembl a sponge, with variously thick trabeculæ and variously wide spa These trabeculæ are all accurately lined with endothelium, and con of connective tissue with some muscular fibre cells. These tumours usually more or less prominent (*nævus prominens*); they are erec and sometimes pulsatile. Sometimes the tumour merges into neighbouring vessels without distinct boundary, but sometimes it a distinct connective-tissue capsule, which, however, appears to be secondary formation. Sometimes also it is indurated in the cen and the induration may gradually lead to the obliteration of spaces and the destruction of the tumour. These tumours are not usually congenital as the former kind, but they come on in childh at latest, and they may develop out of the other form.

The skin is a frequent seat of the cavernous angioma, especially that of the face and head, but also sometimes of the trunk or limbs. They are also met with in the liver, not forming prominent tumours,

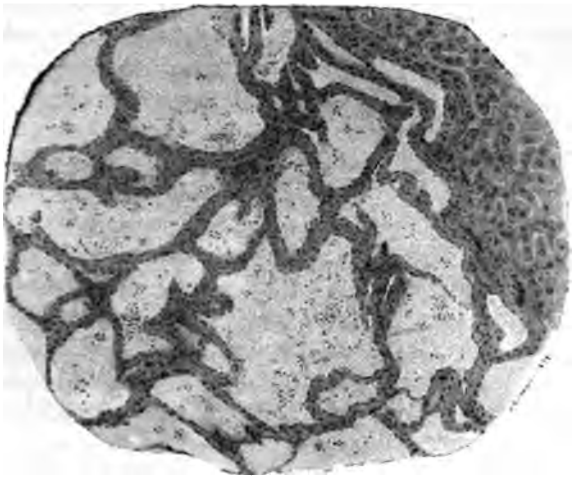

Fig. 138.—Cavernous angioma of liver. The fibrous septa are shown. The spaces between are occupied with blood. × about 50.

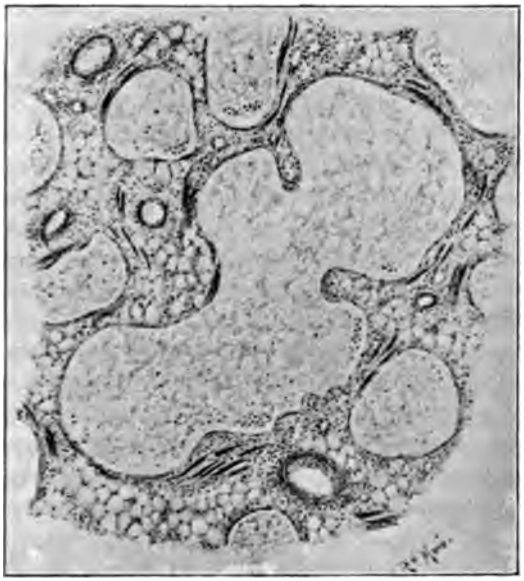

Fig. 139.—Lymphangioma from the subcutaneous tissue of the arm. The spaces are lined with endothelium and contain granular matter in which a few nuclei are visible. × 40.

but simply replacing a piece of liver tissue by cavernous tissue (Fig. 138).

(4) The **Lymphangioma** is a tumour composed of lymphatic vess Two forms have been distinguished here also, namely, the **Plexifo** and **Cavernous**. The former consists of a congeries of dilated ly phatics, while the latter forms a more definite tumour (see Fig. 13 Sometimes the spaces dilate so as to form complex cysts.

These tumours are mostly congenital, and they form a considera proportion of the **Congenital cystic tumours**. The cavernous fo seems to be the cause of the congenital enlargements of the tong to which the name **Macroglossia** is applied, as well as of simi enlargements of the lips (**Macrocheilia**) and cheeks. The term **Ly phangiectasis** is used to designate localized dilatations of lympha vessels. These are met with in various situations. The small whiti yellow figured patches seen so frequently in the small intestine instances of lymphangiectases. In certain cases of elephantiasis th is a great dilatation of the lymphatics which some regard as formi angiomas.

9.—THE GLIOMA.

This is a tumour with the structure of the connective tissue of central nervous system, the **Neuroglia**. In examining a section of brain substance, it is difficult to tell what is really nervous structu and what the supporting connective substance, but when we exam the surfaces of the ventricles we find that the ganglion cells and ner fibres fall away, and just at the surface or ependyma we have what presumably a purely connective substance. When hardened secti are examined, this is seen to consist of a finely reticulated network fibres and round or slightly elongated cells. In the fresh state fibres are not obvious, and we have a granular material. This c nective substance has some of the characters of mucous tissue, a seems allied to it.

The glioma as it occurs **in the brain** does not usually form a well-defi tumour, but, being continuous with the brain substance, has more appearance of a swelling of part of the brain. It is also seen that different shades of colour of different parts of the brain are lost whe glioma takes their place. Gliomas are usually soft in consiste and grey in colour, so as to resemble brain substance, but th sometimes attain considerable density. They occasionally occur small granular or warty projections on the surface of the ventricl but the more important ones involve considerable portions of brain substance.

Under the microscope the glioma is seen to resemble neuroglia, but the cells are much more abundant. There is a well-developed fine or coarse network, and in it cells with oval nuclei. (See Fig. 140.) The cells present considerable variety in size.

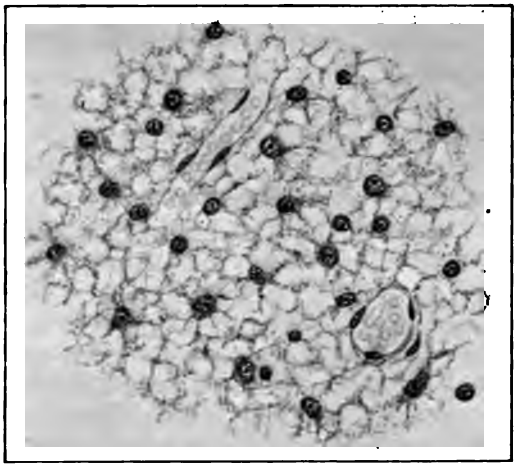

Fig. 140.—Glioma of brain. × 200.

Gliomas, being soft and somewhat cellular tumours, are liable to secondary changes. Hæmorrhage not infrequently occurs, and owing to the blood causing pressure around, the case may end like one of hæmorrhagic apoplexy. The tumour may also undergo fatty or caseous metamorphosis, and if a limited hæmorrhage has occurred the clot may change in a similar way. In this manner a tumour which had originally the appearance of brain substance may change considerably.

The tumour is usually of slow growth and non-malignant, except in the sense that on account of its site it often affects important parts and causes death.

Gliomas occur also **in the retina**, forming soft tumours which fill up the eyeball. The true glioma is an innocent tumour, but sometimes it assumes a sarcomatous character and malignancy is developed.

10.—THE PSAMMOMA OR BRAIN SAND TUMOUR.

The pineal gland contains calcareous particles like grains of sand (*acervulus cerebri*) (see Fig. 141), and tumours are met with in which similar particles are present. It is necessary, of course, to distinguish these from tumours in which simply a secondary calcareous infiltra

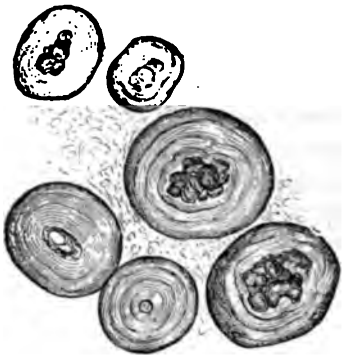
Fig. 141.—Globular particles of brain sand.

has occurred. The psammoma is c posed of soft connective tissue in midst of which are calcareous ma in the form of irregular globes, rod spines. (See Fig. 142.) The commo form is the globe, with rounded pr tions on its surface like a berry. origin and significance of these ma is obscure. They are sometimes to bear a close relation to blood vessels, as in Fig. 142, the tumours have been placed some observers in the category endotheliomas which have undergone calcification. The tumours met with in the pineal gland, choroid plexus, and brain substa

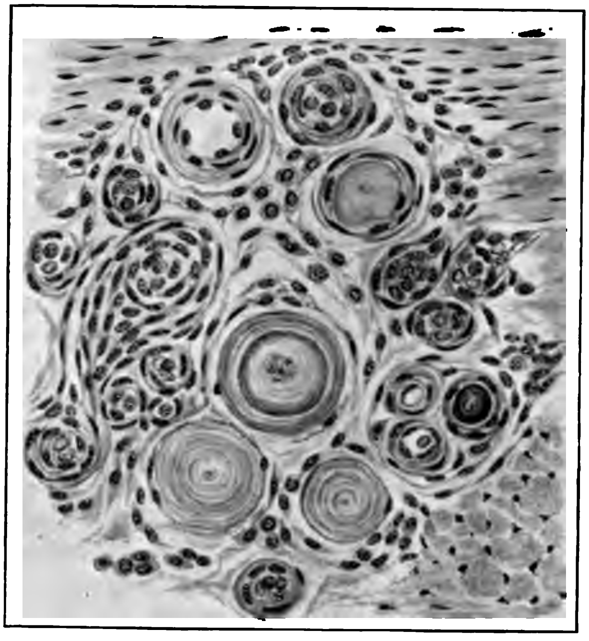
Fig. 142. Psammoma infiltrating dura mater. × 200.

and are usually small. They also occur in the dura mater, wh they form half globular tumours, sometimes as large as a cherry either smooth or irregular on the surface. These tumours may p upon the brain substance (see Fig. 143), but they seldom, if ever, in human subject give rise to symptoms. In the lower animals, especially in the horse, they may attain considerable dimensions and cause marked symptoms.

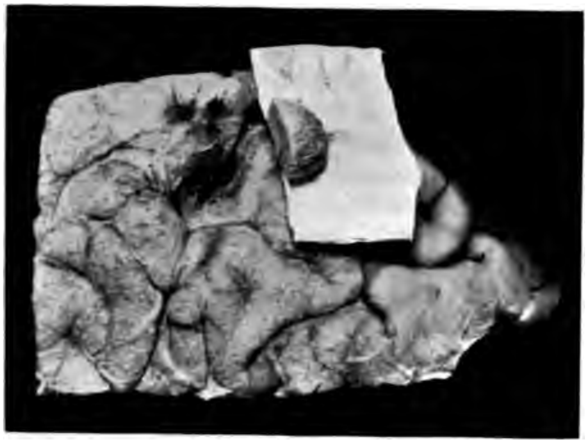

Fig. 143.—Fibro-psammoma of dura mater. Half of the tumour is shown, along with the indentation of the cerebral surface caused by the growth.

The calcareous particles probably arise by deposition around the new-formed vessels. Besides occurring in the simple psammoma, they are met with in sarcomas, myxomas, and other forms of tumour.

11.-THE LYMPHOMA OR LYMPHATIC GLAND TUMOUR.

Under this designation, tumours composed of typical lymphatic gland tissue would be included, but it is doubtful whether such simple lymphomas exist. Such tumours originating in glands would scarcely be distinguishable from simple hypertrophies. Enlargements of lymphatic glands occur as a result of tuberculosis and syphilis, and in leukæmia, but these all belong to distinct categories. The proper tumours arising in lymphatic glands and having their structure are nearly all infective or sarcomatous in character.

12.—THE PAPILLOMA OR PAPILLARY TUMOUR.

By this name is meant a tumour composed of a congeries of exaggerated papillæ like those of the skin, or like the villi of mucous membranes. A papilla or villus consists of a basis of connective tissue in which there is a loop of capillary blood-vessels, and a covering of epithelium. The epithelium is like that of the surface concerned, and may be stratified or in a single layer.

Their commonest situation is the skin, where they form the **Wart** which is an overgrowth of a group of existing papillæ covered wit hard epidermis. (See Fig. 144.) At the surface of the wart the papillæ may be covered over with a continuous layer of epidermis, or the individual papillæ may project independently. The **Horn** (*Cornu cutaneum*, *keratoma*) (see Fig. 145) is also formed on the basis of a group of papillæ, but the hard horny epidermis is greatly developed, and forms a consistent outgrowth of considerable dimensions. (See Fig. 146.) The appearances are simulated in cases of excessive hypertrophy of the toe nails (see Fig. 147). The Condyloma is a syphilitic outgrowth due to exaggeration of the papillæ with very soft epidermis. It occurs near the genital organs mostly.

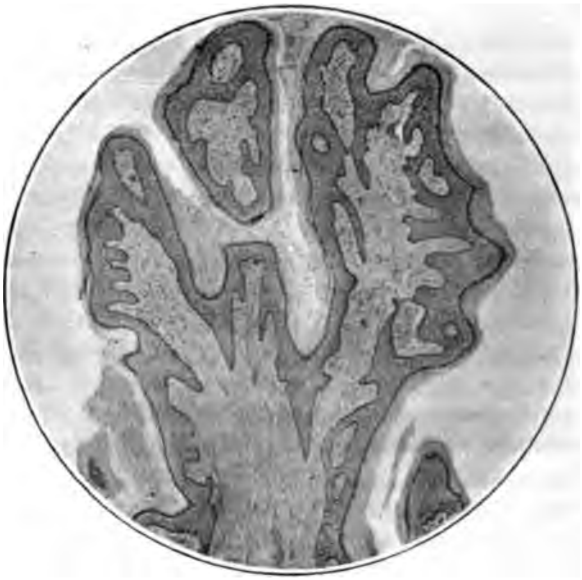

Fig. 144.—Papilloma of skin of neck. × 40.

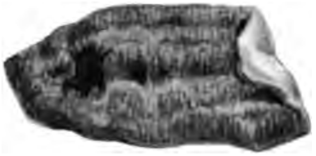

Fig. 145.—Cutaneous horn from face. × 2.

The ordinary wart must be distinguished from the **Congenital soft warts** and **Moles**. These are often pigmented and sometimes covered with hairs. In their structure they not uncommonly contain tissue composed of round or spindle-shaped cells and so differ altogether from the true warts. It is these soft warts and moles which in after life are liable to give rise to sarcomas or cancers.

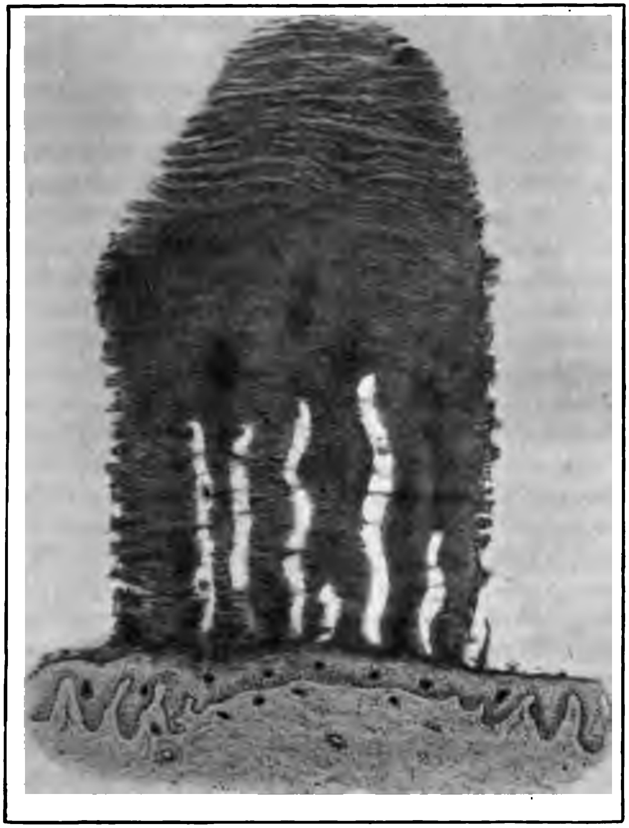

Fig. 146.—Cutaneous horn of face. In the horny epidermis elongated fissures are shown. In some of these fine hairs were present. × 20.

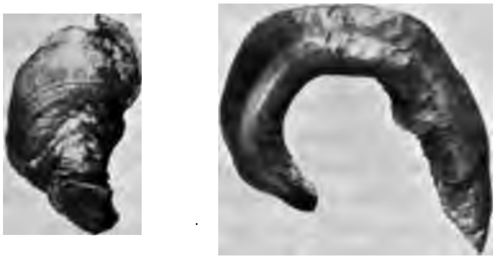

Fig. 147.—Hypertrophy of great toe nails in an aged bed-ridden subject. Actual size.

On **mucous membranes** papillomas may be gathered into local tumours or cover a considerable surface, giving it a shaggy villous appearance. In the **larynx** (Fig. 148) they often form localized prominent tumours, especially on the vocal cords. They are not uncommon in the rectum. (See Fig. 149.) In the **urinary bladder** they are of considerable importance on account of their tendency to cause

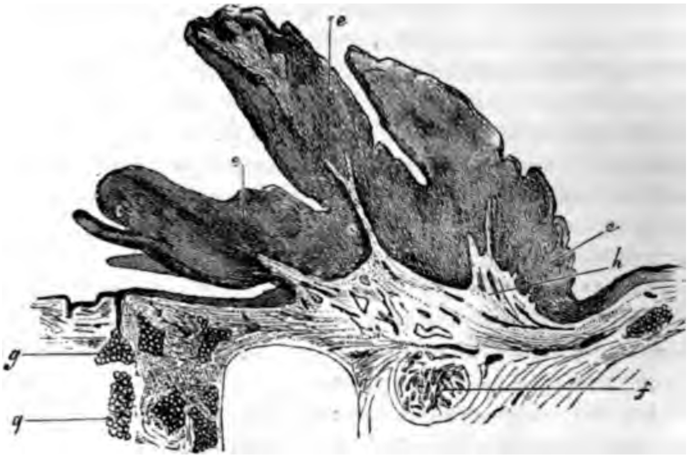

Fig. 148.—Papilloma of larynx: *e*, epithelium; *h*, connective tissue; *g*, mucous glands; *f*, an atrophied gland. × 20. (Cornil and Ranvier.)

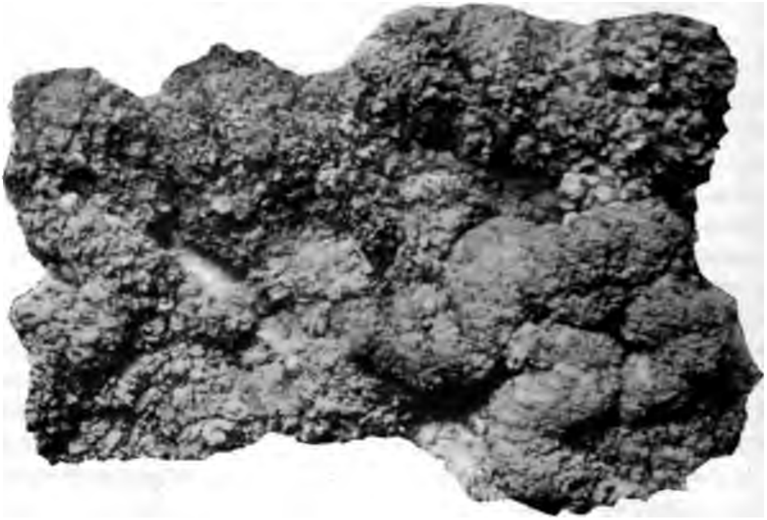

Fig. 149.—Villous papilloma of rectum. The growth completely encircled the lower end of the bowel.

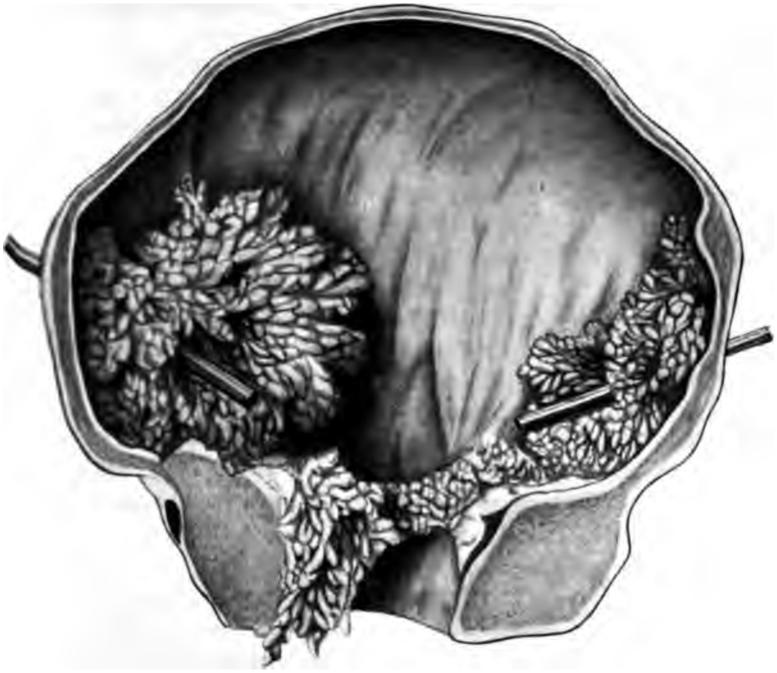

Fig. 150.—Villous papilloma of urinary bladder. The growth is chiefly around the orifices of the ureters.

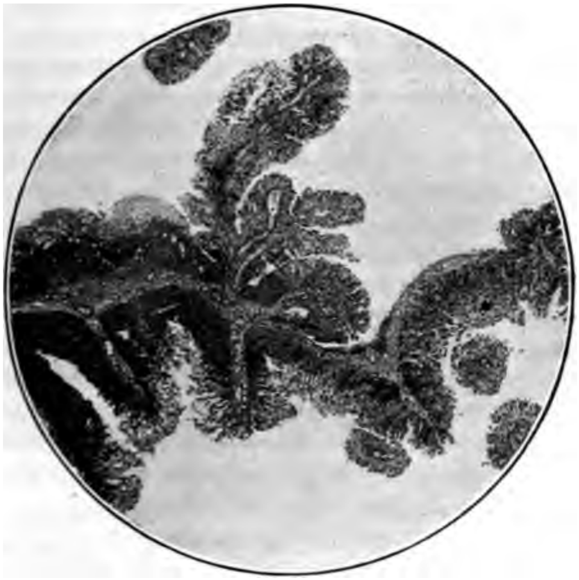

Fig. 151.—Villous papilloma of urinary bladder. × 40.

hæmorrhage. In this situation they may form distinct tumours with long branched papillæ, or there may be a large surface which is simply villous in appearance. (See Fig. 150.) The papillæ are covered with delicate epithelium, and severe and frequent hæmorrhages are common. (See Fig. 151.)

The **papillomatous cyst** is an important form of tumour of the ovary. It is more fully dealt with in the Section on Diseases of the Generative Organs.

The **Pacchionian bodies** of the arachnoid are really papillary formations. Cleland has also described tumours of this region which seemed to arise by extreme hyperplasia of these papillæ.

13.—THE ADENOMA OR GLANDULAR TUMOUR.

The adenoma in its' structure mimics the gland in which it originates. As there are many glands of different structure, so there are various forms of adenoma. The several forms will be more particularly described under the respective organs, and it will only be necessary to enumerate here the most common. We have the mammary (see Fig. 152), the prostatic, the thyroid (see Fig. 153), the renal, the

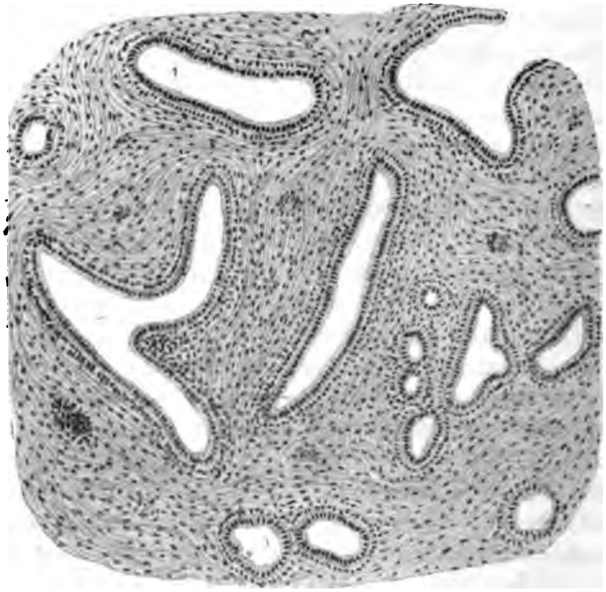

Fig. 152.—Mammary adenoma. Gland spaces are shown in a cellular fibrous stroma. × 64.

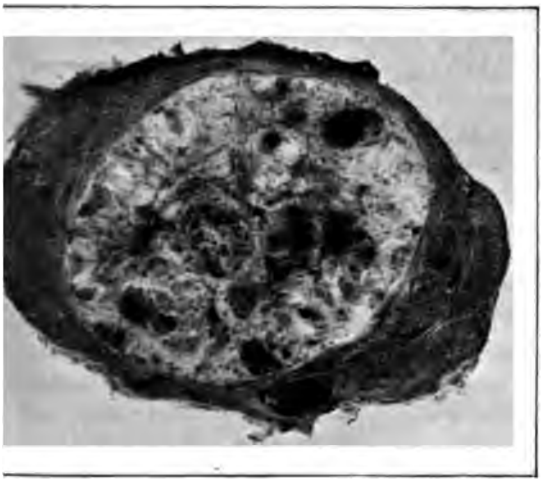

Fig. 153.—Large adenoma of thyroid gland. From a case of goitre.

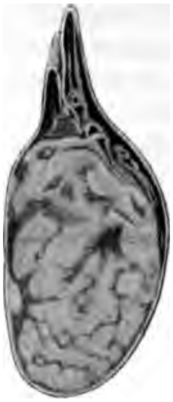

Fig. 154.—Adenoma of suprarenal gland. Actual size.

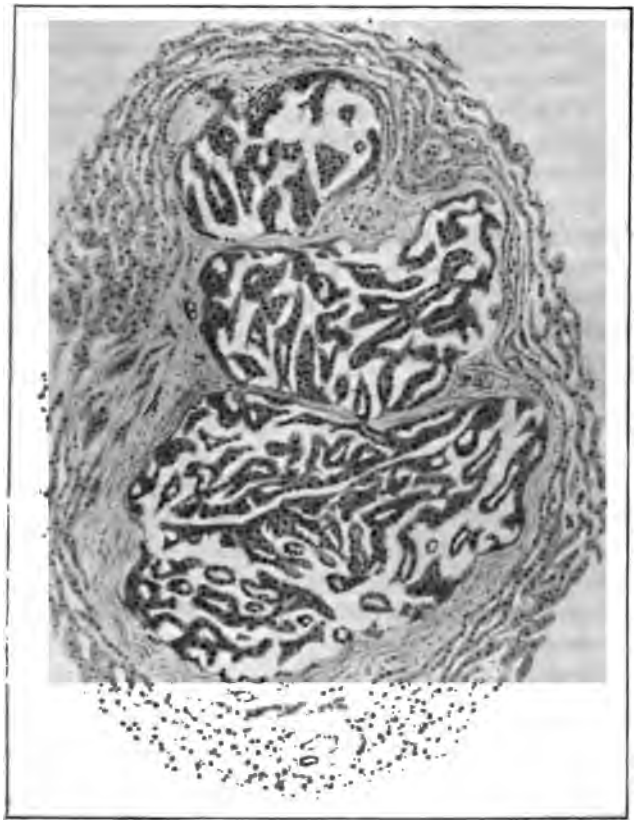

Fig. 155.—Adenoma of liver. × 50.

suprarenal (see Fig. 154), and the hepatic adenomas (see Fig.
Besides these, the so-called mucous polypi, although often form
hypertrophied mucous membrane, frequently contain glandular
which is apparently, in some cases, new-formed. In Fig. 1

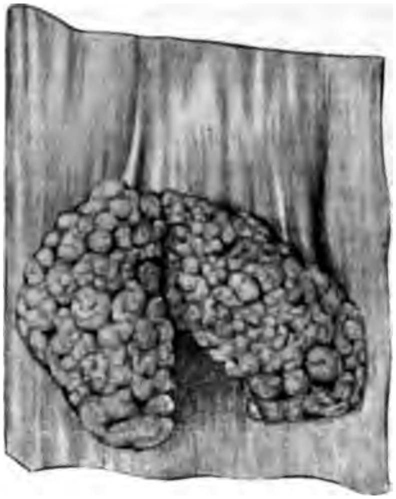

Fig. 156.—Large polypoid and papillary adenoma of stomach.

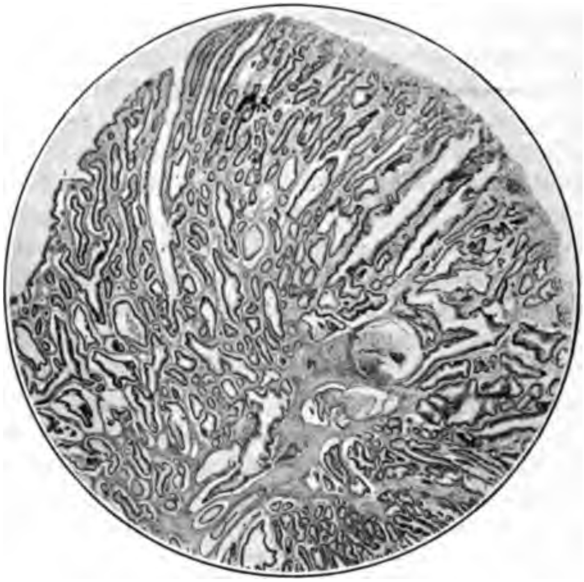

Fig. 157.—Adenoma of intestine. × 12.

represented a large papillary adenoma of the stomach, and in Fig. 157 a section of one of an enormous number of large and small glandular tumours present in the intestine of a child. Again, in ovarian tumours there is frequently a new-formation of gland-tissue out of which cysts develop, so that the tumour is called an adenocystoma.

The term adenoma is not commonly used for tumours composed of lymphatic-gland tissue, although the expression lymph-adenoma is not infrequently employed. As the structure of lymphatic glands differs so markedly from that of the epithelial glands, it is perhaps better to reserve the term adenoma for the latter, and to use that of lymphoma for the former.

A rather unfortunate custom of calling lymphatic tissue "adenoid tissue," without specifying that it is lymphatic, has become somewhat prevalent. It would conduce to clearness if the term lymphoid tissue were used instead.

14.—THE CYSTOMA. CYSTS.

A cyst is a cavity having a definite wall composed of connective tissue lined with epithelium, and containing more or less fluid contents.

The **modes of formation** of cysts are somewhat various, but they all imply the progressive accumulation within the sac of material which has generally the characters of a glandular secretion, but which may be simply serous. Hence, with few exceptions, cysts arise in connection with secreting structures, and these may be the normal glands or else structures which in themselves are of pathological origin. In the former case there is retention and accumulation of the normal secretion, hence the name Retention cyst; and in the latter there is an abnormal tissue producing secretion, which accumulates. Besides these, which are the chief modes of formation, we have subordinate groups arising in some cases by dropsy of existing structures, in others by softenings of the tissue, more especially of tumours, and in others by the transformation of an irregular space, such as a collection of blood has formed, into a definite cavity or cavities containing fluid.

The cysts thus form a somewhat heterogeneous group, and only some of them have the characters of tumours in the sense of forming independent growths. Those arising by softening are entirely subordinate, and are not to be regarded as tumour formations. On the other hand, those arising from accumulation of secretion or dropsical fluid in normal structures may or may not have the characters of tumours. Where there is a progressive increase implying a new-formation of tissue so as to form the wall of the enlarging sac, the characters assume closely those of a tumour. In the case of cysts arising from some new-formed pathological tissue, the characters of

a tumour are complete, and it is advisable to reserve the nam Cystoma for them.

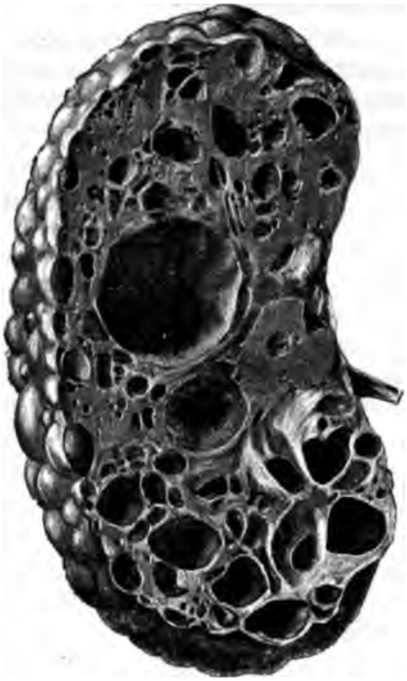

Fig. 158.—Cystic transformation of kidney shown in section. The other kidney was similarly affected.

(1) **Retention cysts.**—These arise from glands by retention of the secretion owing to obstruction or obliteration of the ducts. Exampl of this on a large scale a furnished by cases in which main duct is obstructed. Th obstruction of the ureter ma lead to the conversion of th kidney into a large cystic cavit (hydronephrosis). Obstructio of the cystic duct may cau the gall bladder to form a larg sac; and closure of the orifi of the vermiform appenda may lead to the formation of large cyst. (See further und their respective headings.) C a smaller scale we find in t kidney, liver, and mamma, mu tiple cysts formed by accumul tion of secretion in the tubul and ducts. In the kidney t cysts grow to such an exte that we have a cystic tra formation of the kidney (s Fig. 158).

Mucous cysts also form important group of retenti cysts. They occur in situations where mucous glands are prese their chief sites being the nostrils and communicating cavities, t upper surface of the epiglottis, the larynx, the œsophagus, and in co nection with the glands of Cowper and Bartolin.

The origin and mode of formation of the mucous cyst has been carefully studi by Recklinghausen. The cyst is formed, not out of the gland, but from its du and, as the gland persists, its secretion is thrown into the cyst. This is shown Fig. 159 copied from Recklinghausen's paper. It would thus appear that the pe sistence of the gland is an essential element in the formation of the cyst. In t enlargement of the cyst the power which mucin has of swelling up and absorbi water is of some consequence. Before a regular cyst forms, the orifice of the du is obstructed, usually by inflammation around it. But on account of t peculiarity of mucin just noticed, a small temporary cyst may form without a considerable obstruction of the duct. If a quantity of mucin is discharged into t duct it may swell so much as to be unable at once to escape from the orifice and so form a small cyst, which afterwards discharges. In this way cysts often form in the mucous membrane of the mouth.

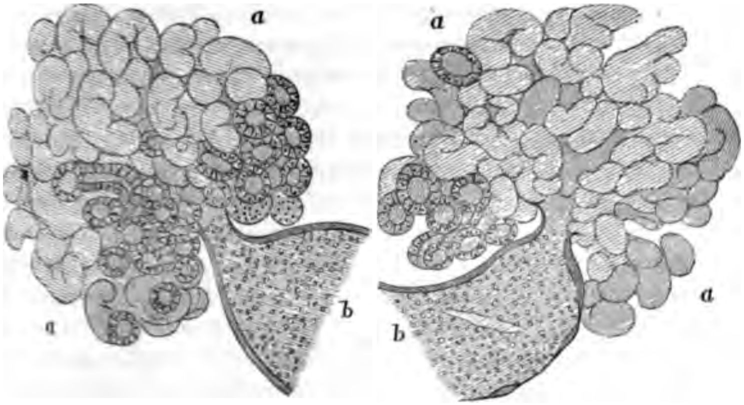

Fig. 159.—Formation of mucous cysts; *a*, the persistent mucous gland tissue; *b*, the dilated duct. × 300. (Recklinghausen.)

Cysts arising in mucous polypi have a similar mode of formation to that just described. The obstruction of the orifices is here the more likely, as the polypus itself usually originates in connection with chronic inflammation of the mucous membrane.

(2) **Cysts by Dilatation of pre-existing spaces.**—Such cysts result from dropsy, as in the ovary, where we often have many cysts from accumulation of fluid in Graafian vesicles (see under Diseases of the Ovaries). Again, serous cysts form by dilatation of lymphatics and of serous spaces in the connective tissue. Another example is afforded by the thyroid gland, where the colloid degeneration in the saccules may lead to the formation of cysts, which enlarge both by accumulation of their contents and coalescence of neighbouring ones.

(3) **Dermoid cysts.**—These are cysts which warrant the name of cystoma, as their walls are not formed from normal tissue, but are themselves of pathological origin. The wall of the cyst is formed of tissue like that of the skin, and the contents are epidermis and sebaceous matter. The simplest of them are found in and under the skin, and they arise from inclusion of fœtal rudiments of the skin. Thus, as already mentioned, the imperfect closure of the branchial clefts may give rise to a dermoid cyst in the neck. Dermoid cysts in the scalp—so-called wens—are very simple in structure (Fig. 160); whilst those of the face are more complex and often contain hairs. Still more complex are the dermoid cysts of the ovary (see Diseases of Female generative organs), which arise apparently from the ovum,

and usually contain, besides skin structures, bone, cartilage, teeth (Fig 161). Such complex cysts might be classed among the

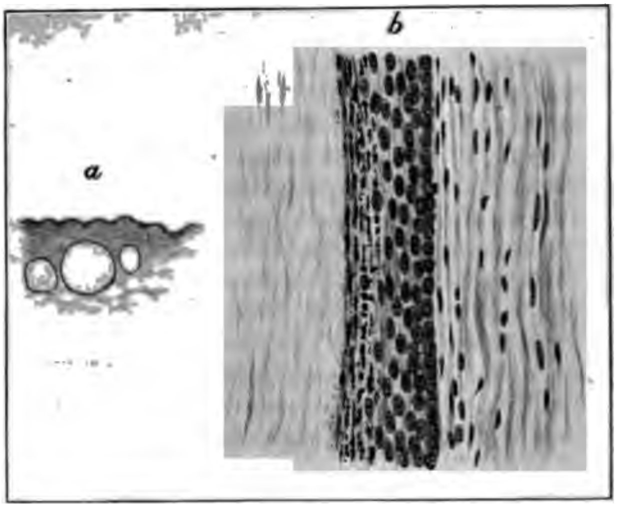

Fig. 160.—Cyst from subcutaneous tissue. (*a*) Natural size. (*b*) Wall of cyst. T the right is the fibrous wall lined with stratified epithelium. To the left altere epithelial cells are indicated. × 200.

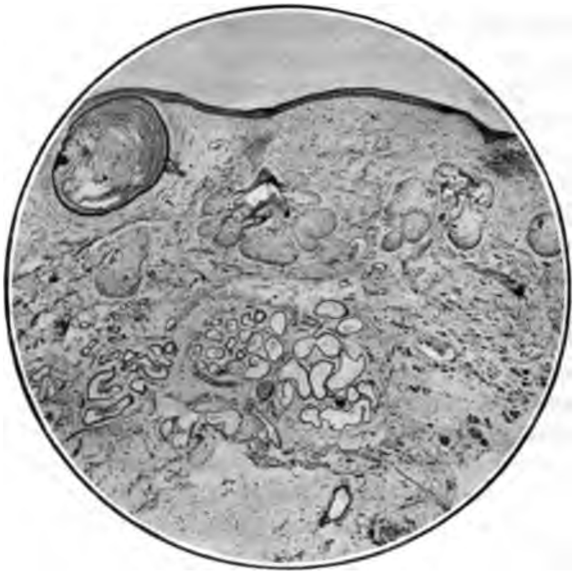

Fig. 161.—Dermoid cyst of ovary. At the upper part the epithelial lining of th cyst is shown. Immediately beneath the surface and to the left is an "epitheli pearl." Sebaceous and sweat glands are abundant. × 16.

tomas. Similar cysts have been met with, though rarely, in the testicles, brain, orbit, lung, peritoneum, and elsewhere.

(4) **Cysts from new-formed gland tissue.**—Cysts of the ovary frequently arise from glandular tissue (see Fig. 162). These tumours will be fully described in the section on diseases of the ovaries. The gland tissue has no ducts, and as the epithelium produces a mucous or other secretion there is great distension, resulting in the formation of cysts. Sometimes the gland tissue is rather in the form of villous or papillary processes, and cysts form by the union of these processes and the accumulation of secretion in their recesses.

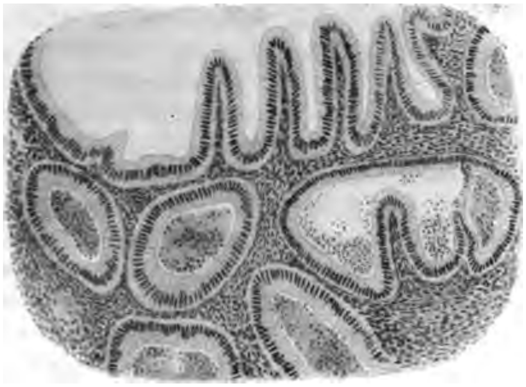

Fig. 162.—From a colloid ovarian cystoma. Gland-like tissue and the beginning of cysts. × 70.

(5) **Parasitic cysts.**—Certain parasitic animals (the Tæniæ or tape-worms) in one phase of their development in different species of animals, occur in the form of cysts (so-called bladder worms). Around these parasites the tissues of the animal form sacs composed of connective tissue. The most important example of this is the so-called hydatid cyst which occurs in connection with the tænia echinococcus and sometimes attains large dimensions.

(6) **Secondary cysts.**—Cysts of subordinate importance are formed chiefly as a result of hæmorrhage or of softening. **Extravasation cysts** result from the changes which may occur after hæmorrhage. This is exemplified in the case of the **apoplectic cyst** where the blood-clot and softened brain substance are replaced by connective tissue containing fluid in its meshes. Such cysts may occur from softening of the brain without hæmorrhage.

Cysts in tumours sometimes originate by dilatation of glandular structures, and hence are very common in adenomas. They also occur not infrequently from softening of tumour tissue (Fig. 163). This is especially the case in large tumours and in those whose tissue is already comparatively soft. All forms of tumours when they grow to a large size are liable to have cavities in their central parts due to softening. On the other hand the soft sarcomas often contain cysts without attaining to large dimensions. These latter cysts often contain blood, and indeed the tumour may present little more than the characters of a cyst filled with blood. **Blood-cysts** are apparently for the most part sarcomas which have undergone this process. (Godlee.)

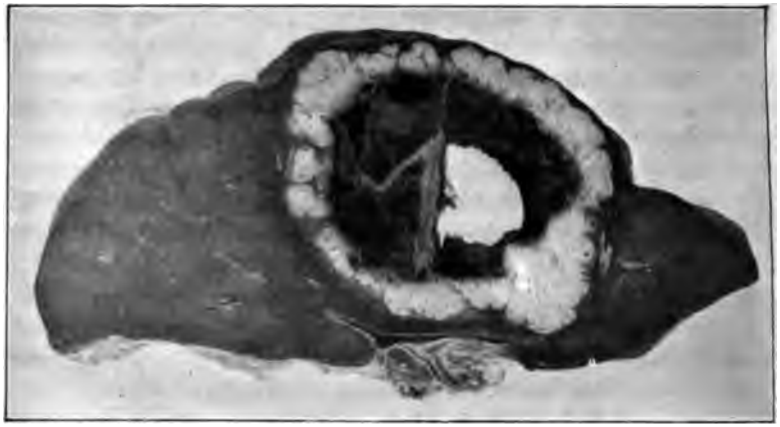

Fig. 163. Large cystic lymphosarcoma of liver. The cavity was filled with blood-stained fluid. The primary growth was in the mediastinal glands.

15.—TERATOMA.

This name has been applied by Virchow to tumours into the structure of which a number of very different tissues enter. The name is derived from τέρας, a monster. The tumour contains various structures of the body as if from an ill-arranged fœtus. Thus, we may have in such tumours, skin, bone, muscle, glands, nervous tissue.

Some of these tumours arise by the abnormal inclusion of a portion of a double monster (see p. 39). They are most frequently met with in positions where double monsters are usually attached to each other, namely, in the sacral region (see Fig. 164) or further up the back, and in the head and neck. They are also somewhat frequent in the ovary, where they may arise by an irregular developmental process, the ovum endeavouring to develop some of the perfect tissues of the body.

The **Sacral teratomas and those of the head and neck** are the more typical ones. The former are frequently of large size (see Fig. 164).

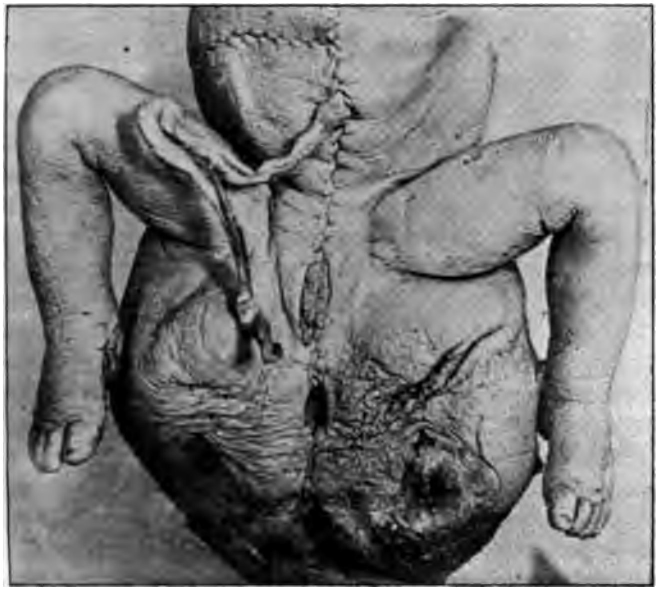

Fig. 164.—Congenital sacral teratoma.

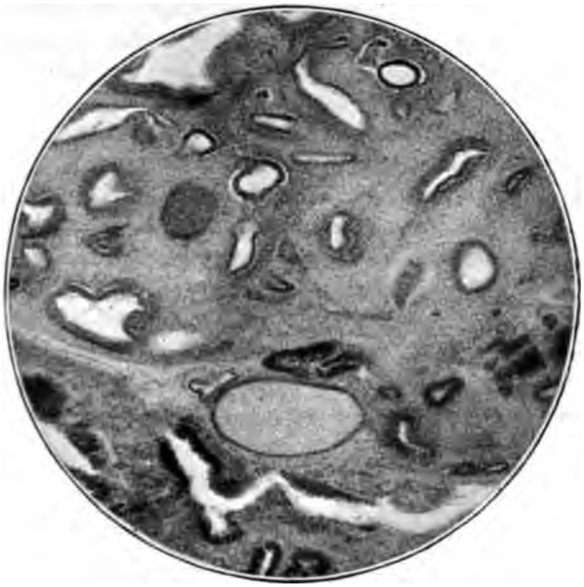

Fig. 165.—Congenital sacral teratoma. A large number of glandular and cystic spaces are shown with occasional islets of cellular cartilage. × 40.

They frequently contain pieces of bone which simulate the b of the fœtus, and also cartilage and brain substance. Not i quently they contain cysts, and may be indeed chiefly compose these (see Fig. 165). The walls of the cysts recall the struc

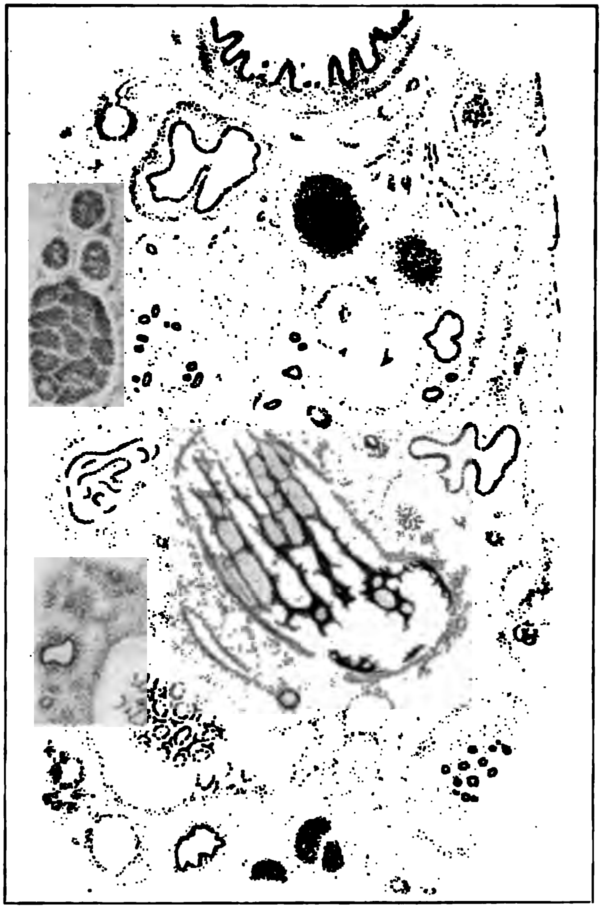

Fig. 166.—Intracranial teratoma. The various elements depicted were present in one small section of the tumour. Glandular structures of very different forms, cartilage, bone, voluntary and involuntary muscle, etc., were found. × 20.

of the skin, which sometimes contains hairs, etc., and of mu membranes, and their contents are sebaceous matter and mu Besides cysts the tumour commonly contains much adipose ti glandular structures of somewhat indefinite character, and volun muscle.

The teratomas of **internal organs** do not usually represent such complete systems or so many different tissues as the sacral. They are most frequent in the ovaries, but also occur in the peritoneum, testes, lungs, etc. Intracranial teratomas are occasionally met with (Fig. 166). The pineal gland has been shown to be the place of origin of some of these. The dermoid cysts already considered are the chief representatives of this group in internal organs.

It must be confessed that the exact position of these tumours cannot be regarded as fully determined, although the researches of Wilms and others have done much to throw light on the subject. A case examined by the author had some peculiar features which approximated it to the class of true tumours. The child lived for two years after birth, and the tumour became much larger, even in proportion to the growth of the child during that period. Most of the tissues mentioned above were present, namely, cysts of the dermic and mucoid character, adipose tissue, voluntary muscle, gland tissue and bone. A striking peculiarity, and one which constitutes the chief divergence from other cases of the kind, was the presence of cancerous tissue. Not only was this tissue present in the tumour, but there were numerous secondary tumours of typically cancerous structure in the liver.

Literature of Typical Tumours.—In addition to the general references already given, the following will prove useful: *Fibroma*—Virchow's Geschwülste, i.; Morton and Coats, Glasg. Med. Jour., iii., 145, 1870; Recklinghausen, Die multiplen Fibrome der Haut, 1882; Kriege, Virch. Arch., cviii., 466; Westphalen, ib., cx., 29; Philippson, ib., 602; Heisig (Intestine), Inaug. Diss. Greifsw, 1897; Geldner (Labium), Inaug. Diss. Greifsw, 1897; Aschoff, Lubarsch & Ostertag, Ergebnisse, 1900. *Myxoma*—Müller, Arch. f. Anat. u. Phys., 1836; Virchow, Arch., xi., 286, and Geschwülste, i., p. 396; Borst, loc. cit., 1902. *Chondroma*—A. Cooper, Surgical Essays, 1818; Virchow, Geschwülste, i., 435; Murchison, Edin. Monthly Jour., 1852; Syme (Congenital enchondroma), Lancet, 1855, p. 116; Ernst, Ziegler's Beiträge, 1900. *Osteoma*—Weber, Die Knochengeschwülste, 1856; Virchow, Geschwülste, ii., 1 and 53 (Odontoma); Bland Sutton (Odontoma), Tumours Innocent and Malignant, 2nd edition. *Myoma*—A considerable number of isolated cases of Rhabdomyoma are recorded. A list of these is given by Kolessnikow in Virch. Arch., lxviii., 554, and by Huber and Boström, D. Arch. f. klin. Med., xxiii., 208; see also Cohnheim, Virch. Arch., lxvi.; Marchand, ib., lxxiii. and c. (in last-mentioned paper, Glycogen found in muscle); Bland Sutton, Tumours, 2nd edition; Helbing, Centralb. f. allgem. Path., ix., 1898. *Leiomyoma*—Virchow, Geschwülste, iii.; Judassohn (Multiple Myomas of skin), Virch. Arch., cxxi., 1890; Brodowski (Myoma of stomach), Virch. Arch., lxvii., 1876; Recklinghausen, Die Adenomyome und Cystadenome, 1896. *Tubercula dolorosa*—Wood, Edin. Med. and Surg. Jour., 1812; Virchow, Geschwülste, iii., 236; Hoggan and Virchow, Virch. Arch., lxxxii., 1880; Malherbe, Congrès International, Copenhague, 1884, i., 117. *Neuroma*—Virchow, Geschwülste, iii., 233; R. W. Smith, On Neuroma, 1849; see also New Syd. Soc. Reprint; Wood, On painful subcutaneous tub., 1812; Paget, Lect. on surg. path., 3rd ed., p. 490. On *false neuroma*, see especially Recklinghausen, Ueber multiplen Fibrome, 1882; Kriege, Virch. Arch., cviii.; Westphalen, Virch. Arch., cx.; Philippson, Virch. Arch., cx.

Plexiform Neuroma—Bruns, Virch. Arch., l., 1870; Lecroix and Bonnaud, A de méd. expér., ii., 1890; Thomson, On neuroma, etc., 1900. *Papilloma*—Clel Glas. Med. Jour., 1861. *Cystoma*—Virchow, Geschwülste, i., Lecture ix.; Bu Internat. Ency. of Surg., iv., 655; Recklinghausen, Virch. Arch., lxxxiv., Godlee, Path. Trans., xxvii., 270; Bland Sutton, On tumours, 2nd edit Aschoff, Lubarsch & Ostertag, Ergeb., 1895; Marckwald, ibid., 1895. *Terat* —Freyer, Virch. Arch., 1873, lviii., p. 509; Lütkemüller, Stricker's Jahrbüc 1875, p. 66; Wilms, Deutsches Arch. f. klin. Med., lv., 1895, Ziegler's Beit xix., 1896; Carey, Johns Hopkins Hosp. Bull., Nov. 1902; Borst (with r ences), Die Lehre v. d. Geschwülsten, 1902.

SECTION IX.—CONTINUED.

B.—ATYPICAL TUMOURS.

I. **Sarcoma.** Definition. Structure; cells, intercellular substance, blood-vessels. Place of origin. Mode of growth; local malignancy and metastasis. Changes in structure; induration, ossification, cystic formation, ulceration, etc. Individual forms. 1. Round-celled, 2. Spindle-celled, 3. Giant-celled, 4. Pigmented, and 5. Plexiform sarcomas. Other forms described.

II. **Carcinoma or Cancer.** Definition. Structure; cells, stroma, blood-vessels, lymphatics. Origin; from existing epithelium, shown in many cases, hence its localities where epithelium exists. Influence of age and sex. Growth and extension; frequently by infiltration; ulceration; secondary tumours in lymphatic glands; generalization by implantation of grafts; usual seats of secondary tumours; their large size; their mimicry of primary tumours. Retrograde changes; fatty degeneration, chiefly. The local nature of cancer. Individual forms. 1. Flat-celled epithelioma, including Rodent ulcer, 2. Cylinder-celled epithelioma, 3. Soft or medullary cancer, 4. Scirrhus, 5. Colloid cancer, 6. Melanotic cancer, 7. Mucous cancer, 8. Endothelioma.

I.—SARCOMA.

In its literal meaning this term simply indicates a fleshy tumour, and it was formerly applied in a very indefinite way. Under the influence of Virchow, however, it has come to include a group of tumours, which, although in certain respects differing in structure, yet present such features in common that they form a consistent class of themselves.

Definition.—The sarcomas may be defined as tumours which originate in one or other of the forms of connective tissue, but differ in structure from their mother-tissue chiefly in respect that the cells greatly preponderate over the intercellular substance, and also that they frequently differ greatly in size and shape. This definition includes the origin of the tumour, and refers also to the atypical character of the structure. It may be added that in its mode of growth the sarcoma is also atypical, having the characters of malignancy already referred to.

Structure.—Sarcomas have been somewhat aptly compared in structure to inflammatory new-formations. We have already seen that the tendency of these, as exemplified in the granulating wound, is to develop into connective tissue. The round cells pass into spindle cells, and then the connective tissue develops out of the latter. The round and spindle cells may thus be regarded as the preparatory, or in a certain sense embryonic stage of connective tissue. In sarcomas we have tumours composed of round cells, and tumours composed of spindle cells, with little or no tendency to further development, as if the embryonic form had been stereotyped for the whole life of the tumour. Besides these forms sarcomas sometimes contain giant-cells (myeloplaques). We know that cells of this nature occur normally in growing bones where, as Wegener and Kölliker have shown, they exercise an important function (osteoclasts), and they are not uncommon in granulation-tissue, even apart from bone. They also are to be regarded as connective tissue structures, and as belonging to a developmental stage of connective tissue.

From the definition given above of sarcoma it will be apparent that the tumours included in this class will vary very greatly in structure and other characters. They will vary in the first place according to their tissue of origin, because, although in general following the type of granulation-tissue, yet they usually carry with them, especially in the characters of the intercellular substance, some indications of the mother-tissue, so that it might be possible to distinguish as many forms of sarcoma as there are typical tumours of the connective tissue series But even when derived from the same tissue the tumours may vary according to shape, size, and abundance of cells, so that still greate complexity is thus introduced.

In the diagnosis of actual cases reference should be made to origin as well as to structure and mode of growth.

Sarcomas differ according to the form of cells and character of intercellular substance. So far as **the Cells** are concerned the chief form are those already mentioned, namely, round, spindle-shaped, and giant-celled. The tumour is usually homogeneous in its structure, at least in its recent parts where not altered by degenerations or further developments, and so it is generally possible to distinguish sarcomas according as they are round-celled, spindle-celled, or giant-celled. There are however, cases in which the cells are variously shaped, partly round and partly spindle-shaped. These are sometimes called mixed-celled sarcomas.

As the characters of the individual forms of connective tissue ar determined by their **Intercellular substance**, so sarcomas are generally named according to the nature of their intercellular substance, *e.g.*, **Fibrosarcomas, Myxosarcomas, Chondrosarcomas**, and so on. We have also tumours of striated or smooth muscle which take on the sarcomatous mode of growth, and are hence called **Myosarcomas.**

The **Blood-vessels** of sarcomas are generally thin-walled, and they run usually in immediate contact with the tumour tissue. In some cases they are supported by complete or rudimentary connective tissue, which may divide the tissue into alveoli, and so give rise to an appearance resembling that of cancer (*alveolar sarcoma*). Sometimes the sheath of the vessels undergoes a peculiar transformation into a hyaline substance, which forms a mantle round the vessels, and gives a plexiform character to the tissue (*plexiform sarcoma, cylindroma*).

Pigmentation is not infrequent in sarcomas, especially in those arising in pigmented situations such as the skin and eyeball. The pigment is usually in the cells, but may be in the intercellular substance.

Place of origin of sarcomas.—As connective tissue is of nearly universal occurrence, sarcomas may arise in almost any situation. They originate, however, for the most part where connective tissue in some form is abundant. Thus the bones, the skin, the mammæ, and the lymphatic glands are frequent seats of origin. They are also common in the testicle and the brain, but are somewhat rare as primary tumours in other organs, in the muscles and in the lungs.

The place of origin has an important influence on the structure of the tumour and on the transformations and degenerations to which it is liable.

Mode of growth and transformations of sarcomas.—The sarcoma grows by multiplication of its own elements, and it is often surrounded by a capsule so as to be apparently self-contained. Even when so delimited, however, it generally presents the characters of local malignancy. The tumour grows along the existing connective tissue of the part, and outside the apparent boundaries, even outside the capsule there are already the multiplying cells of the tumour.

This was very characteristically observed by the author in a case of pigmented sarcoma, where the pigmented cells were plainly visible in the connective tissue outside the mass of the tumour.

The tumour thus growing along the connective tissue sometimes moulds itself on the structure, causing atrophy of the special constituents of the tissue which it replaces.

Besides this local malignancy, sarcomas frequently give rise to **Secondary tumours** at a distance. As a general rule the lymphatic glands are not secondarily affected, but in sarcomas of the foot, the tonsil, the testicle, and probably the kidney, they are liable to be involved (Butlin). This fact implies that either in their origin or in process of growth the sarcomas of these localities come into relation with the lymphatic vessels. Either with or without an intermediate affection of the glands extension is liable to occur by the blood so as to reach the lungs, which are the most frequent seats of such metastatic growths. It may pass on by the systemic circulation to a large number of different situations. The secondary tumours repeat exactly in structure and mode of growth the primary one, so that we may have, in the lungs or elsewhere, typical spindle-celled tumours, or even cartilaginous or ossifying sarcomas.

The sarcomas are somewhat liable to **metamorphoses and transformations**. The soft and quickly growing ones are specially prone to fatty degeneration and softening, so that cysts may form in this way. Hæmorrhage in these cases is not an infrequent occurrence. The tissue may also show a tendency to develop into the mature tissue of its kind. Thus a fibrous development may occur in the sarcomas of membranes, or a partial formation of cartilage or bone may take place, and this tendency may be so marked as to give a distinctive character to the tumour, so that we may speak of an **Ossifying, Indurating, or Calcifying sarcoma.** This peculiarity may give rise to mistakes in diagnosis if a part of the tumour which has undergone transformation be examined, hence it is always best to seek for the growing margin of the tumour for examination.

Besides this the sarcomatous tissue may be **mixed** with other tissues. **Gland-tissue** is most frequently thus associated, especially in the mamma and the testicle. It is sometimes difficult to determine whether the gland-tissue found in mammary tumours is simply the remains of the gland or newly-formed. The presence of gland-tissue is important as it frequently, by dilatation, gives rise to **Cysts.** These cysts often give a special character to the sarcomas, especially in the mamma and testicle, the association being indicated by the term **Cystic sarcoma.** The tumour tissue frequently grows into the cysts, forming the so-called **Intracystic growth,** and often gives a peculiar character to the tumour when divided by the knife.

Sarcomas coming to the surface usually incorporate the skin, converting it into their own tissue, and then **Ulcerate.** The ulcer is thus formed of the tumour tissue, which may be excavated by softening, or may pout outwards into a fungating mass, liable to bleed (*Fungus hæmatodes*).

The individual forms of sarcoma.—The most convenient division of sarcomas is according to the form and other characters of their cells.

While such a division is adopted, however, it must be remembered that tumours occur in which various forms of cells are present.

1. The **round-celled sarcoma** is also called the granulation sarcoma and the encephaloid sarcoma. It is composed of round or slightly oval

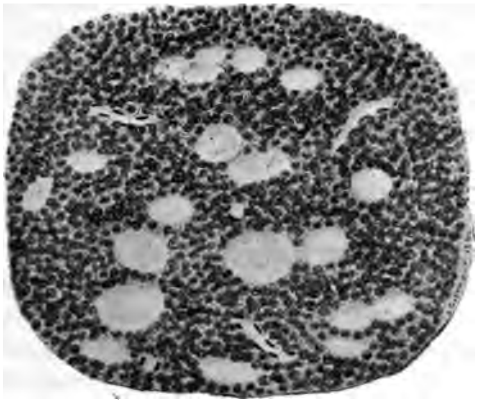

Fig. 167.—Small round-celled sarcoma infiltrating adipose tissue.

cells generally about the size of the polymorphonuclear leucocytes of the blood (see Fig. 167), but sometimes much larger (see Fig. 168).

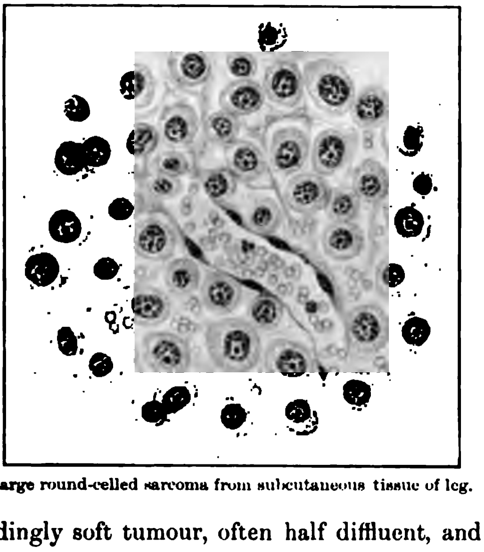

Fig. 168.—Large round-celled sarcoma from subcutaneous tissue of leg. × 800.

is an exceedingly soft tumour, often half diffluent, and has usually grey medullary appearance. Its blood-vessels are in the form mainly large capillaries, whose walls are embryonic in structure and often present varicose or aneurysmal dilatations. The vessels are lia rupture, and so these tumours often present interstitial hæmor Between the cells there may be some intercellular substance. sometimes homogeneous and becomes opaque with acetic acid (sarcoma), or it may be somewhat fibrous or reticulated.

This form of sarcoma is met with in the skin, where it may ori in a congenital soft wart or mole: in the subcutaneous tissue 168); in the bones—forming the majority of the so-called med

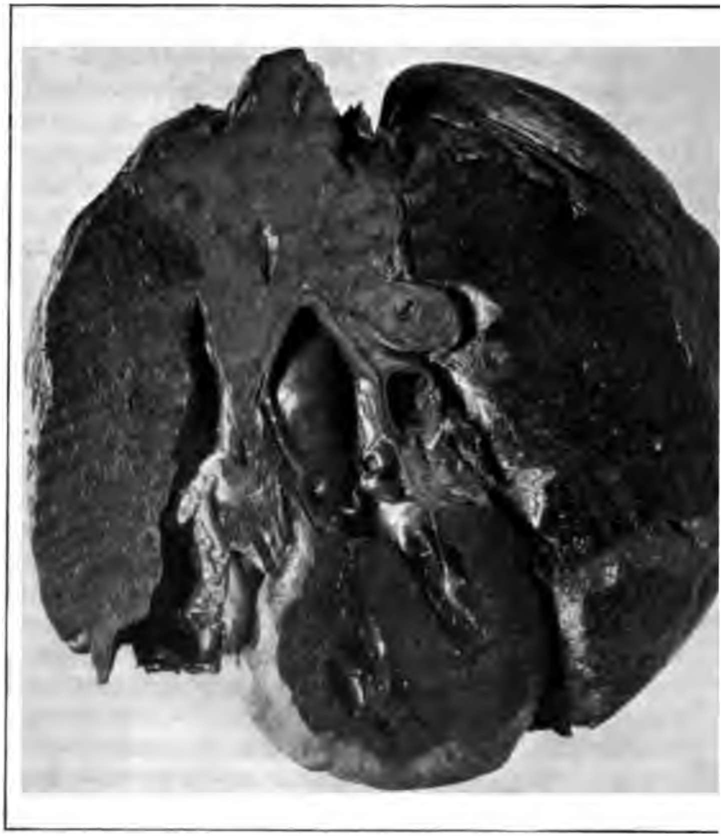

Fig. 169. Lymphosarcoma originating in the lymphatic glands at the root of t right lung. The extensions of the growth are shown on section.

cancers of bone; in the muscles; in the glands—especially the m and testicle; in the brain and elsewhere. Being a soft tumou delicate vessels it more readily produces secondary tumou metastasis than other sarcomas. It is also usually a tum rapid growth, and commonly very imperfectly defined from the surrounding tissue.

The **Lympho-sarcoma** deserves special mention as a variety of the round-celled sarcoma. It originates from lymphatic glands, its commonest seat of origin being the glands at the root of the lungs (see Fig. 169), but it also arises in the glands of the mesentery. It closely resembles the round-celled sarcoma in microscopic structure (see Fig. 170), and presents very typically the characters of local malignancy, involving and moulding itself upon neighbouring structures, such as the pericardium, heart-wall, veins, and bronchi in the case of mediastinal tumours, and the intestine in the case of mesenteric ones.

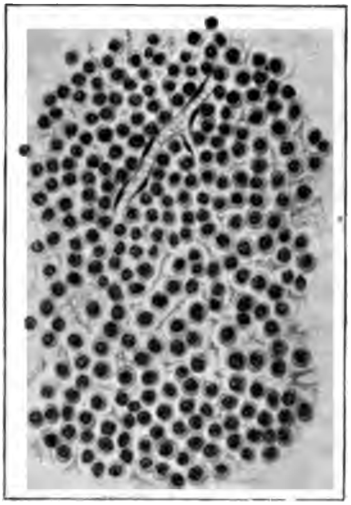
Fig. 170.—Lympho-sarcoma of mediastinum. × 300.

2. The **spindle-celled sarcoma** is also called the fibro-sarcoma, and corresponds with Paget's class of recurrent fibroids, and Lebert's group of fibro-plastic tumours. The cells are spindle-shaped, like those in the deeper layers of a granulating wound, and there is comparatively little intercellular substance, the tumour being mainly composed of masses of spindle-cells. There is always, however, a certain amount of intercellular substance, which consists of fibres

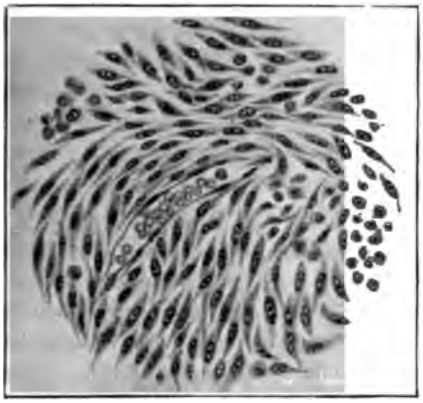
Fig. 171.—Small spindle-celled sarcoma. × 300.

generally of some density. The cells are arranged in bundles, which to a certain extent interlace like the bundles of fibre-cells in the myoma. There are great varieties in the size of the cells, some tumours being composed of very small cells, and these are usually soft (see Fig. 171), others show large cells (see Fig. 172), while at the opposite extreme are cases where the spindles are gigantic. When viewed in mass the individual spindles may not be apparent, but they are usually easily isolated, unlike the fibre-cells of the myoma (see Fig. 173). These tumours, except the small-celled forms, are usually firmer than the round-celled sarcomas, and may even approach the fibroma in hardness. Many of them show a tendency to more complete organization into fibrous tissue, cartilage, or bone.

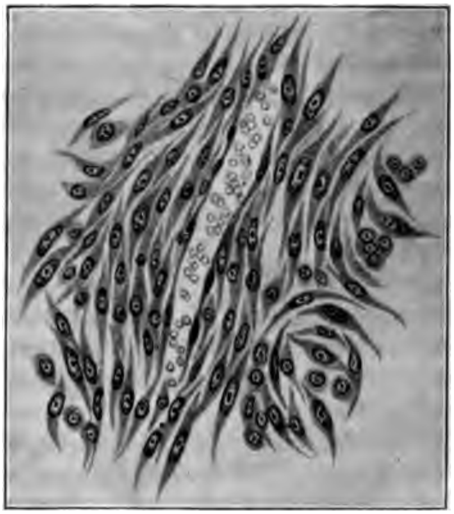

Fig. 172.—Large spindle-celled sarcoma. From a secondary tumour in the lung. × 300.

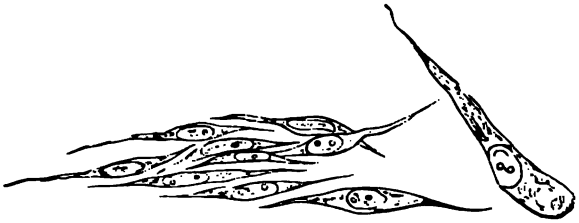

Fig. 173.—Large cells isolated from a spindle-celled sarcoma. × 300.

The spindle-celled sarcoma occurs frequently in the periosteum, and in that case is firmly attached to the bone (see Fig. 174). It is also met with in or under the skin (see Fig. 175), in muscles, in the testicle, etc. It is a frequent tumour in the mamma, and here it not infre-

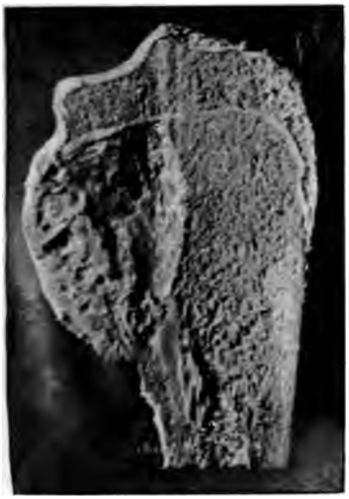

Fig. 174.—Spindle-celled sarcoma of tibia growing from upper end of diaphysis. It is eroding the bone.

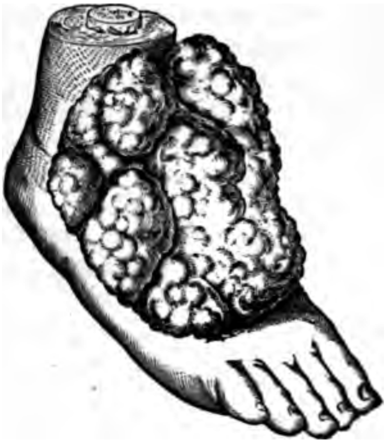

Fig. 175.—Large fungating spindle-celled sarcoma of the foot. (VIRCHOW.)

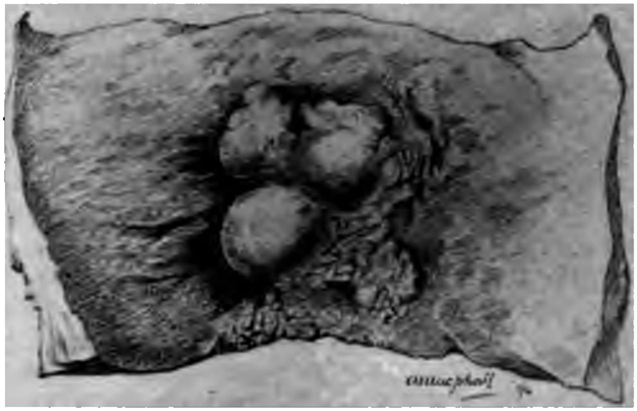

Fig. 176.—Primary spindle-celled sarcoma of rectum. The lower edge of the figure corresponds with the anal margin.

quently forms the adenoid sarcoma and the cystic sarcoma. occasionally found in the intestine, and especially in the rectum Fig. 176).

The spindle-celled sarcoma is usually a distinctly defined tur but often, as in the case of the periosteal form, its boundarie not defined, and it advances by incorporating neighbouring struct (See Fig. 174.) Although prone to return after removal, it has tendency than the round-celled form to give rise to secondary tum by metastasis.

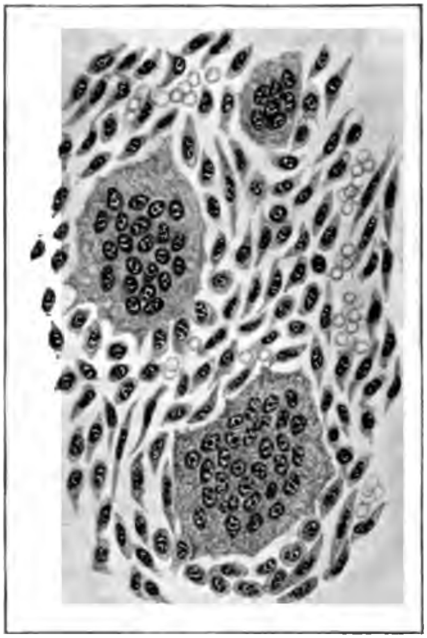

Fig. 177.—Giant-celled sarcoma of femur. × 300.

3. **Myeloid or Giant-celled sarcoma** is a tumour in which giant-cell is characteristic, but never forms the only sarcoma element, there being generally spindle cells and sometimes round ce great abundance (see Figs. 177 and 178). The giant-cells are in gr or smaller number in proportion to the others, and in the same tu they may present various proportions in different parts. The tu tissue is soft, and very often of a brown colour. Cysts not infrequ develop by softening.

[illegible] sarcoma occurs in connection with bone, and [illegible] the medulla. This is especially the case the long bones, where the tumours originate in the cancellated tissue at the extremity—the most usual situation being the lower end of the femur or the upper end of the tibia. (See under Diseases of Bone.)

Myeloid sarcoma is also met with outside bones, growing from the periosteum, especially of the jaws. Many tumours, to which the name **Epulis** is given, are myeloid sarcomas (Fig. 178).

The myeloid sarcoma is, for the most part, slow of growth, and does not usually produce secondary tumours.

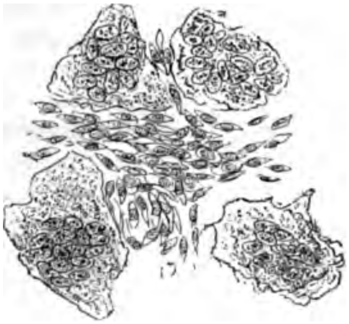

Fig. 178.—Giant-celled sarcoma. Malignant epulis. × 175.

4. **Melanoid, melanotic, or Pigmented sarcoma** always originates in a situation where pigment already exists, the eye or skin. The cells of which it is composed are usually spindle-shaped, but may be round, and from the first they tend to show an aggregation of brown or black pigment in their substance (Fig. 179).

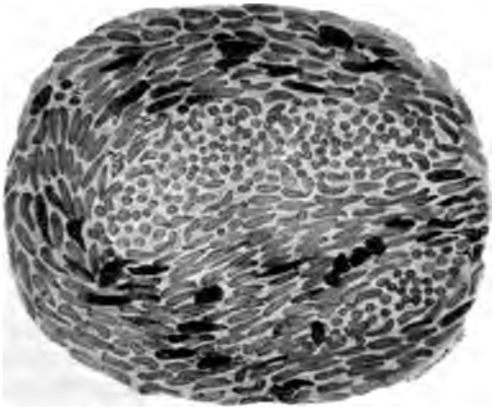

Fig. 179.—Pigmented sarcoma. The cells are spindle-shaped. Some are deeply pigmented. × 350.

The pigment is very irregular in its distribution. In a melanotic tumour there may be portions unpigmented, and even in the pigmented parts some cells are free from pigment. This is well seen in Fig. 180.

The melanotic sarcomas have a great tendency to metastasis, and as the material is conveyed by the blood there are pigmented tumours formed in a great variety of organs and tissues where they may grow to great dimensions, though the original tumour may be small.

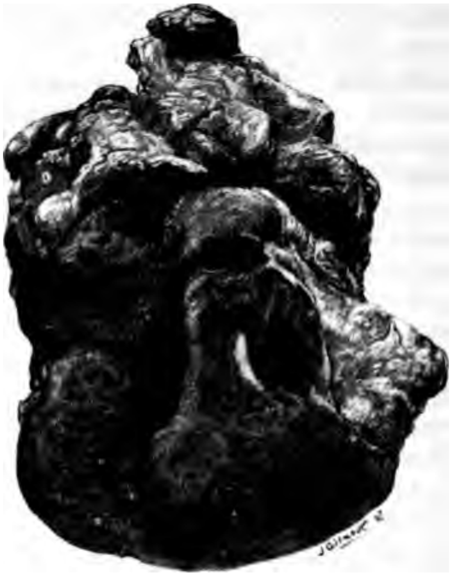

Fig. 180.—Large melanotic sarcoma from anal margin.

It is necessary to distinguish from these proper melanotic sarcomas those become pigmented from blood. In the former the pigment is brown or black the first, being obviously elaborated by the cells. In the latter the pigment

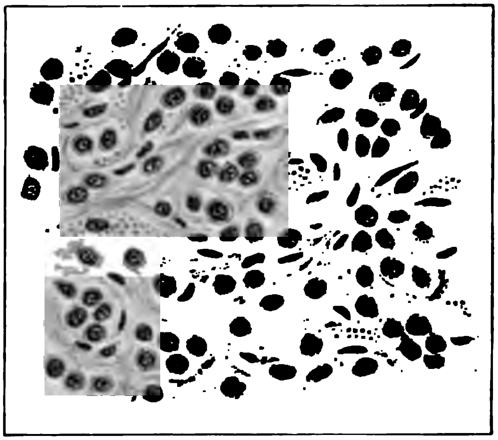

Fig. 181.—Chloroma. Cells of rounded form corresponding in size and structure with the larger lymphocytes of the blood are seen in groups in the midst of fibrous tissue. Small refractive granules which give the reactions for fat are seen scattered throughout the tissue. × 300.

or yellow, and the pigmentation may be related to a special weakness of the vessels allowing of hæmorrhage.

The term **Chloroma** has been applied to a new formation of a peculiar greenish-yellow or grass-green colour. It occurs primarily in the periosteum of the face and head, and may lead to secondary tumours of similar colour in the liver, kidneys, etc. The colour, which is regarded by some as due to small refracting granules of fat, readily disappears on exposure to air and light. This fact has suggested the possibility of the colour being due to some oxidizable product allied to lipochrome. Chloroma is generally classified along with the round-celled sarcomas, but is regarded by some as a variety of leukæmia (see Fig. 181).

5. **Plexiform sarcoma or Cylindroma** is a name applied to a form of tumour whose relations are somewhat obscure, and it probably includes more than one kind. The peculiarity of the tumour is the existence of cylinders and rounded structures having a hyaline character, like mucous tissue. In the centre of the cylinder there is often a blood-vessel, so that the hyaline material clothes it like a mantle. Then, between the cylinders of hyaline material there are frequently masses of cells which may form long processes, so as to give a close resemblance to cancer, to whose cells these may also conform in general appearance.

The origin of these cylinders is not perfectly clear. In some cases it may be that we have a combination of sarcoma and myxoma, but this does not account for the peculiar form of the cylinders. A more probable explanation is that the cylinders arise by hyaline or mucous degeneration of the adventitia of the blood-vessels, and this is confirmed by the fact that they are often arranged around the vessels. In this way we should have a sarcoma in which a peculiar transformation occurs in the external coats of the vessels. It is on this view that the name *plexiform angiosarcoma* is applied to this form of tumour.

The tumour as a whole is often of a gelatinous appearance, or it may be that the gelatinous material is seen to be in separate spaces throughout the tumour. It occurs in the orbits and its neighbourhood, or the upper and lower jaws; it may form part of the constituents of tumours of the parotid, and it is also found in the brain and its membranes and the peritoneum, where it may grow to a large size.

Besides these forms of sarcoma several others are sometimes distinguished and designated by special names. Thus we have **Alveolar sarcoma** in which the cells, which are generally round and frequently large, are arranged in loculi, so that both in the characters of the cells and their arrangement there may be a resemblance to cancer. The place of origin and the intimate relation between the cells and the loculi are generally sufficient to make the diagnosis clear.

The **Osteoid chondroma** and **Osteoid sarcoma** are closely allied forms of tumour of bone. In both there is a great tendency to the formation of osseous tissue, often of imperfect structure. The recent and growing parts of the tumours are composed of cells like those of ossifying cartilage, or of spindle-shaped or stellate cells with stiff fibrous intercellular substance.

The **Psammoma** is often regarded as a variety of sarcoma. No doubt spindle celled sarcomas sometimes contain calcareous particles such as these alread described. With less justification the **Glioma** is sometimes included with th sarcomas. The term **Endothelioma** is used by some to designate tumours whic have a structure indistinguishable from carcinomas, but arise in presumably non epithelial structures. We prefer to include them among the cancers, where the will be described. **Deciduoma malignum** is by some regarded as a form of sarcoma (See under Generative organs.)

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II.—CARCINOMA OR CANCER.

The term cancer is a clinical one, expressing the malignant characte of the tumour. Like sarcoma it was formerly applied in a general way and included most sarcomas. The delimitation of the sarcomas b Virchow has led to a stricter definition of the cancers.

Definition.—The carcinoma is a tumour taking origin in epitheliu and having an epithelial structure, but in the arrangement of th structure and in its mode of growth presenting atypical characters.

Structure.—The **Cells of cancers** are epithelial in origin and struc ture, but differ according to the form of epithelium from which the are derived. Thus we have flat or pavement cells, cylindrical cells and glandular epithelial cells. Again, the cells do not alway correspond strictly with the typical cells of the same kind, but a they are produced in great numbers, and as, correspondingly to th general type of epithelium, they lie close against each other, the often present great varieties in shape and size. This applies especiall to the glandular forms. The various forms of cells will be agai referred to in describing the varieties of cancers. The cells alway grow in larger or smaller masses, lying close together without inter cellular substance, so as to form the so-called "cell-nests," which ar characteristic of cancers (Fig. 182). The cut surface of cancers whe scraped by the knife often yields a fluid, the so-called **Cancer-juice**, i which are present groups of cells as they have been removed from the spaces in which they lie.

The **Stroma** encloses the cell masses, and supports the blood-vessels necessary for the nourishment of the tissue. The cell masses are epithelial, and they may be derived from epithelial cells which have been transported from a distance, as is the case in secondary cancers, but the stroma is always derived from the local connective tissue and local blood-vessels. The stroma may be nothing more than the pre-existing connective tissue of the part, perhaps with some inflammatory increase, as indicated by the presence of round cells, but in other cases, and especially in secondary tumours, it forms a well-defined meshwork of characteristic appearance. The stroma may be formed, not of ordinary connective tissue, but of bone and cartilage, this fact showing that the stroma is of purely local growth, and also that bone and cartilage have close relations to ordinary connective tissue.

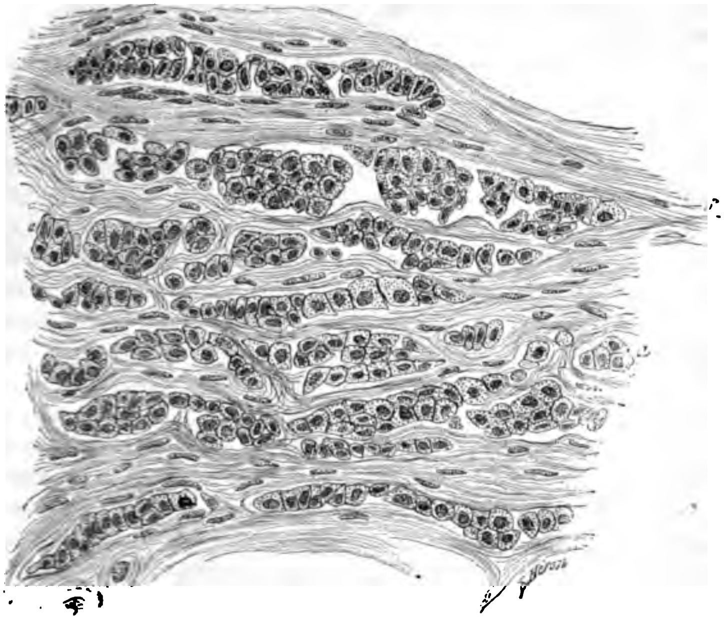

Fig. 182. —Section of cancer of mamma from a recent nodule. Epithelial cells in spaces formed by connective tissue; these are sometimes in single rows, and by multiplication form larger masses. ×200. (CORNIL and RANVIER.)

In a case observed by the author of cancer of the stomach with secondary tumours in the ribs, the secondary tumours formed enlargements of a firm character. Microscopic examination showed trabeculæ, formed partly of bone and partly of cartilage, which radiated from the surface of the rib. Between these trabeculæ were the characteristic epithelial structures of the cancer.

Where a cancer produces a well-formed stroma along with the epithelial masses, it will probably grow more readily into a distinct tumour than where the epithelial masses depend for their nourishment on the existing blood-vessels. In this latter case the cancer will commonly present more the characters of an infiltration of the tissues with epithelial structures, and this infiltration may be associated with such irritation as to lead to considerable new-formation of hard connective tissue, giving sometimes a markedly fibrous character to the structure, as in scirrhous cancer.

As we have already seen (page 273) according to Ribbert, the stroma plays a most important part in the development of the cancerous tumour.

The **Blood-vessels** in cancers run, as has been indicated, in the connective tissue stroma. They consist of wide capillaries with the usual arterial and venous connections. The great tendency which cancers present to extend by the lymphatic system suggests some special structural connection with the **Lymphatic vessels.** According to Cornil and Ranvier such a connection can be demonstrated by injection. If a cancerous tumour, before being laid open, be punctured with the needle of a hypodermic syringe and a watery solution of Prussian blue be injected, the material first runs into the alveoli around the puncture, mapping out, as it were, a series of cavities, and then passes on into the lymphatic vessels, issuing by their extremities divided in removing the tumour.

Origin and Locality of carcinoma.—In regard to their place of origin it may be said that cancers always arise where epithelium (or endothelium) is normally present, and there seems no doubt that the epithelium of the cancer takes origin in the similar cells of the normal tissue.

Virchow, although distinguishing sarcoma from cancer as a connective tissue tumour, asserted that the cancerous tissue takes origin in connective tissue. The great authority of Virchow has caused this view to be perpetuated more than it otherwise would have been. It was controverted first by Thiersch, who showed that in epithelial cancer the cells can be seen to originate from the epidermic cells. Waldeyer, in a series of very elaborate papers, went over most of the seats of cancer, and showed that in these the cancerous tissue is directly derived from the existing epithelium.

In many situations the actual **Connection with the existing epithelial structures** can be traced, especially if the growing edge of the carcinoma be examined. Thus in a section of an epithelioma of the skin, or of the lip or tongue, the cylinders of epithelium which form the essential constituents of the tumour, can be often traced into direct connection with the Malpighian layer of the epidermis.

(See Fig. 183.) Again, in some cases of primary cancer of the kidney it can be seen that the tumour is arising by direct transformation of the kidney tissue. The primary cancer of the kidney is in many cases not a tumour added on to the kidney, but it is generally a portion of, or sometimes the whole kidney, which has undergone an enormous enlargement while keeping its general shape; it is in fact the kidney or portion of kidney transformed. And when we examine the marginal parts of such a tumour we find the epithelium of the uriniferous tubules in an active state of proliferation, the tubules getting distended with new-formed epithelium. The epithelium also, in its state of activity, is altering its shape according to the mutual pressure of the cells, so that it sometimes gets elongated and tailed.

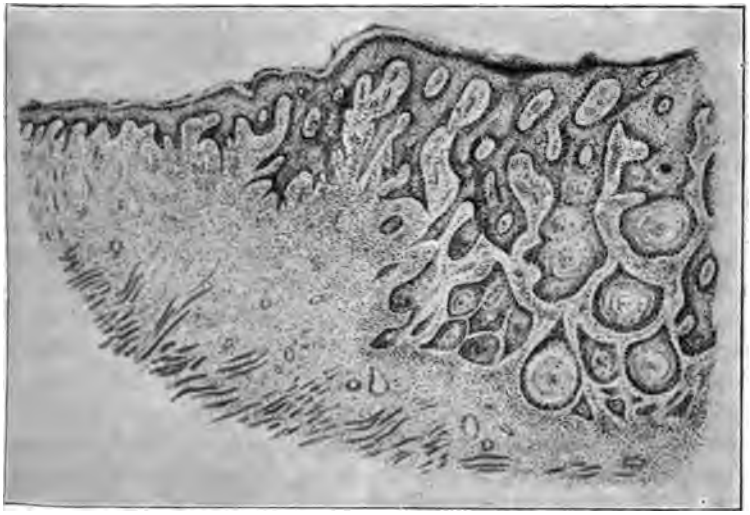

Fig. 183.—Epithelioma of lip. The edge of the tumour showing the connection of the ingrowing epithelium with the normal epidermis. × 20.

This activity of the normal epithelium seems to be the regular preliminary to the cancerous formation where it takes origin in glands. In the mamma, for example, there are some cancers in which the tumours have a special connection with the ducts (Duct-cancer; often co-existing with eczema of the nipple and areola). In these the epithelium of the ducts, from the nipple downwards, shows great activity, so that the ducts become distended with epithelium, which in accumulating loses its normal cylindrical form. The epithelium of the acini of the gland also partakes in the active new-formation. Similar processes have been observed in cancer of the uterus and elsewhere. We may therefore conclude that the first stage formation of a cancer is an abnormal activity in the epitheli a particular locality.

The next stage in the development of the cancer is that its epi elements break bounds a tend out into the surro tissue. It is this atypical sion which is the most cha istic feature.

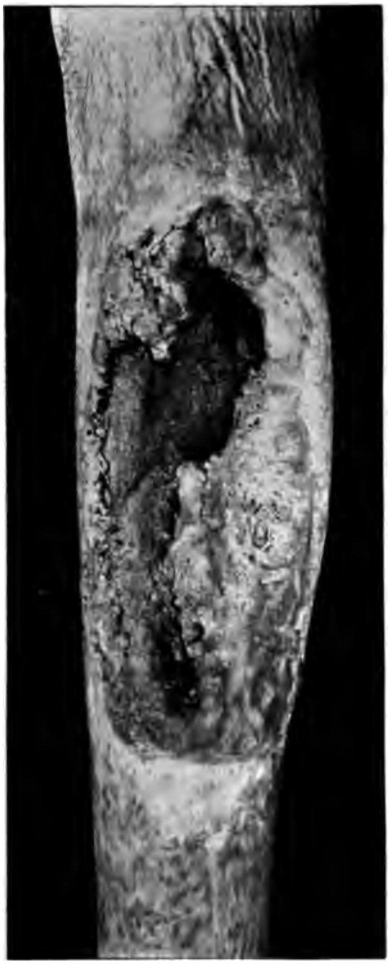

Fig. 184.—Epithelioma originating in an old ulcer of the leg with excavation and penetration of the underlying tibia.

As already indicated, may originate in any l where epithelium (or en lium) is normally presen occurs in the skin and n membranes, in glands, i lungs, in the brain, and (on serous membranes. shows great preferences f tain localities. Thus th eminent seats of cancer a lower lip, tongue, mamma, and stomach. Many of preferences can be accoun by local peculiarities. Ca the lower lip and tongu been ascribed to the irrita short or rough tobacco-pip the jagged edges of cariou The mamma and uterus involution before other of the body, and as canc disease of advanced lif earlier decadence of these may determine the freque the occurrence of cancer in Again, exposure to injury, tion, and friction have already alluded to as deter the localities of cancers. Ulcers which fail to heal frequently cancerous, and the margins of sinuses in connection with dea may be similarly affected (see Fig. 184).

The connection of cancer with irritation of the epithelial str is forcibly shown in cases of cancer occurring in chimney-sweepers, workers with asphalt and tar, or workers in paraffin refineries. In the latter case there are in the skin, apart from the cancerous growth, numerous elevations of the epidermis, of one of which Fig. 185 is a reproduction, indicating that the irritant has acted on the epidermis in a special manner.

Age and sex have important influences on the origin and locality of cancer. It is almost unknown during infancy and childhood, and is very rare under thirty years of age. The writer has met with examples at the ages of twelve, twenty, and twenty-five. It is frequent from thirty-five till seventy-five. After this age it becomes less frequent, and is rare in extreme old age. It seems strange that a disease characterized by undue activity of growth of certain elements should occur especially when the body generally is losing in vigour. An explanation of this was suggested by Thiersch, to the effect that, as cancer consists essentially in an exaggerated growth of epithelium, which invades the neighbouring structures, especially the connective tissue, the cause may lie rather in a falling away of the resistance of the other tissues than an extra vigour of the epithelium. The occurrence of cancers in old cicatrices (see Fig. 186), which consist of a connective tissue of low vitality, and the engrafting of cancer on a chronic tuberculous lesion, such as lupus (*Lupus cancer*), would lend some force to this view. The liability of the mamma and uterus to cancer causes a considerable preponderance in the female sex, which is only partly redressed by the frequency of cancer of the tongue, lip, and œsophagus in the male.

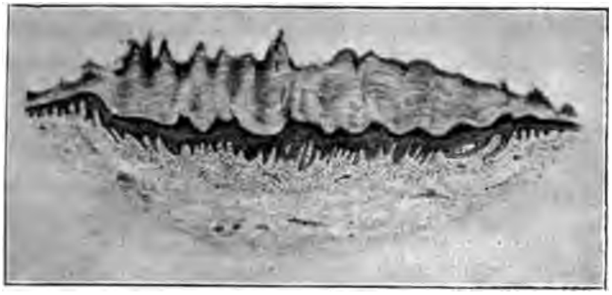

Fig. 185.—Section of skin from the neighbourhood of a cancer in a paraffin worker. There is a striking hypertrophy of the epidermis producing a warty condition. ×12.

Parasitic protozoa in cancers.—Much attention has been paid within recent times to the presence in cancers of bodies which by many are interpreted as minute animal parasites belonging to the protozoa, to the class of sporozoa, and to the genus coccidium. There are undoubtedly round or oval bodies which are present in some of the epithelial cells in almost all cancers. Some of these are shown in Fig. 187. They present certain colour reactions with staining agents, which show them to be different from the ordinary cell structure. They are present chiefly in the protoplasm of the cell, but have also been described in the nucleus. These so-called parasites in the epithelial cells are supposed to stimulate the latter, and being animal cells they may enter into conjunction with the epithelial cells and induce the special action.

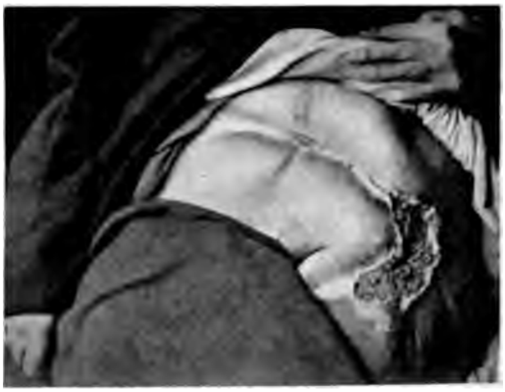
Fig. 186.—Epithelioma originating in the scar of a burn.

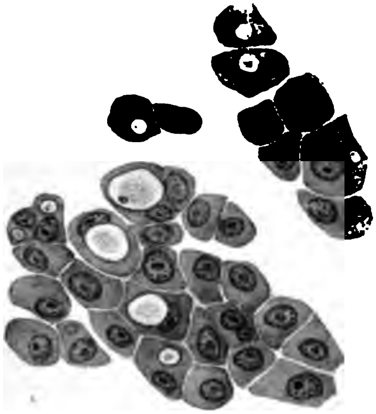
Fig. 187.—From a section of a cancer showing the so-called cancer bodies. In addition to the nuclei, which are oval bodies of uniform size, there are round or oval bodies of various sizes generally more or less clear, except in the centre.

This view has been supported by the citation of certain facts connected with parasitic protozoa and their action. In the disease Coccidiosis (see under Animal Parasites) a parasitic protozoon grows in the epithelial cells of the hepatic ducts, and leads to a marked proliferation of epithelium, so that gland-like tissue is formed, in which new-formed connective tissue supports the growing epithelium. The parasite, the coccidium oviforme, in a case recorded by Gubler, produced in the human subject a number of tumours in the liver which were taken to be cancerous. Further, in Molluscum contagiosum (see under Diseases of the Skin), there is a great new formation of epithelium, so that what is virtually an epithelial tumour is produced. In this case there grow in the epithelial cells bodies which are regarded by some as parasitic protozoa (the so-called molluscum bodies). The contagious nature of the disease suggests a parasitic origin, but this has not been definitely proved.

In the case of cancer a parasitic origin might explain the malignancy of the disease and its spreading character. When it once begins, a cancer spreads by inducing the normal epithelium to take part, and the multiplication of a parasite might explain this. It would also explain the general malignancy should the epithelium and the parasite be transplanted together. On the other hand, there are features in cancer which are difficult to explain on the view of a parasitic origin. The local character of the primary tumour is one of these. In coccidiosis and molluscum contagiosum we have, as in diseases due to parasitic microbes, many lesions produced by the parasite, but in cancer a multiple origin is never seen, and even two primary tumours are rare. Again, cancer is a proper tissue growth, and in different forms of the disease the tissue produced shows great variety. This seems inconsistent with a parasitic origin, unless there be many different kinds of coccidia. On the whole, the presumption seems in favour of the parasitic origin, but there are many facts to be elucidated before it can be fully accepted.

The literature of this subject is already very extensive. (See a list of 112 references by Stroebe, Centralbl. f. Allg. Path., 1894, p. 11.) Some of the principal papers are: Russell, Brit. Med. Jour., 1890, vol. ii.; Soudakewitch, Ann. de l'Inst. Pasteur, vol. v., 1892; Ruffer and colleagues, Journal of Path., vol. 1, 1892, p. 189 (with history and literature); *ibid.*, vol. i., 1893, p. 395; *ibid.*, vol. ii., 1893, p. 3; Clarke, Cancer, Sarcoma, and other morbid growths, 1893; Pianese, Histol. and etiol. of Carcinoma (Trans.), 1893; Borst, Die Lehre v. d. Geschwülsten, ii., 1902.

Mode of growth and extension of cancer.—We have seen that cancer is characterized by the atypical growth of the epithelium. The growing epithelium sends out buds or offshoots which penetrate into the underlying or surrounding tissue. In this way a primary cancer does not usually grow into a considerable tumour, but rather insinuates itself amongst the tissues around. Hence we speak of **Cancerous infiltration** as characteristic of most tumours of this kind.

The question of the **Inoculation of cancer** is one which naturally suggests itself, and many experiments have been performed, both on man and animals to determine the possibility of such inoculation. These experiments have not so far been absolutely conclusive. It is not uncommon, however, to find what may be called

Auto-inoculation. Thus a cancer of the posterior wall of the urinary bladder will sometimes extend to a point on the anterior wall where the tumour comes in contact when the bladder is empty.

The growing cancerous processes frequently lead to much irritation in the connective tissue, so that we may have, in cancer of the lip, for instance, the extremities of the cancer cylinders buried in masses of round cells. Sometimes there is considerable cicatricial formation apparently induced by the insinuating cancerous processes. On the other hand, the tumour may lead to little irritation, and the cancer with its characteristic stroma may grow amongst the normal tissues merely acting on them by pressure.

The effect on neighbouring structures is to cause atrophy of their proper elements by pressure, so that the cancer takes the place of the normal tissue.

If the cancer originates at a surface, or in its growth comes to present itself there, then its tissue, being less resistant than the normal structures, breaks down and we have ulcers following. **Ulceration** is generally present in cancers of the skin and mucous membranes, and in the later stages of glandular cancers.

Besides this local malignancy cancers frequently produce tumours at a distance. It is well known that the **Secondary tumours** mostly occur in the **lymphatic glands**. This may be explained partly by the anatomical connection already mentioned, and partly also by the fact that the growing cancerous process extending in the direction of least resistance will readily pass into the spaces in the tissues which are the radicles of the lymphatic vessels.

It seems not improbable, on the other hand, that cancer has a special affinity for lymphatics. The author has observed, for example, in cases of secondary cancer of the lung, that although brought to the lung by the pulmonary artery, the cancerous growth has been chiefly in the lymphatic vessels to begin with. In one such case it was quite common to find, in the neighbourhood of the pulmonary artery, the lymphatic spaces in the sheath filled out with cancerous masses. (See under Affections of the Lungs.)

The cancer forms a true new-formation in the lymphatic glands. The tumour-formation mostly begins at the peripheral parts of the gland, these being the parts to which the afferent vessels are distributed and here the characteristic epithelial structure is developed. It is sometimes very striking in the earliest periods of infection of the glands to find layers of cancerous tissue at the periphery enclosing the follicles of lymphatic tissue. The latter tissue undergoes atrophy, so that we may have only here and there groups of round cells representing the proper lymphatic gland tissue in the midst of cancerous tissue. Finally all trace of the normal tissue disappears.

It is an important practical question whether the enlargement of lymphatic glands in connection with cancers is always a true secondary infection. There is no doubt that, just as in the primary tumour, the cancerous growth is often associated with irritation, sometimes leading to cicatricial conditions of the gland (especially in colloid cancer), but in that case there is the cancerous infection as well. In the case of ulcerating cancers, on the other hand, irritating products of decomposition may be carried to the glands, and give rise to a simple non-cancerous enlargement. Hence enlargement of glands is of less significance in ulcerating cancers than in those which are not ulcerated, but in all cases enlargement of the glands is to be looked on with suspicion.

The cancerous infection may for a time remain confined to the primary seat and the lymphatic glands, but it is liable to extend further and **become generalized.** This occurs by the material of infection reaching the blood, and being carried by it to distant situations. For the most part this metastasis by the blood only occurs after the lymphatic glands have been for some time affected, and the infection takes place from the lymphatic glands. It may be that in some cases there is a direct extension from the primary tumour to the blood. **Carcinomatosis** is a term sometimes employed to designate a wide-spread generalization of the growth.

The infection may occur from the lymphatic glands after the complete removal of the primary tumour. This had happened in a case observed by the author in which, after excision of an epithelioma of the vulva, the lymphatic glands in the groin, having been affected, gave rise to multiple secondary tumours in various organs.

Having reached the blood the infection is carried throughout the body, and **Grafts are implanted** in various organs. If the lymphatic glands be in communication with the systemic veins, then the infection will be carried to the lungs and on into the systemic arteries, but if they be in connection with the portal circulation, then the liver will be the organ to which they will be conveyed. This secondary (or tertiary) infection of distant organs occurs by **Embolism**, portions of cancerous tissue, perhaps only young cells, being planted in various organs, and tumours are produced having all the characteristic structure of cancer.

The metastatic growth does not occur so readily in some organs as in others. It is commonly said that the situations in which primary cancer occurs are comparatively seldom affected secondarily. Thus the mamma, uterus, and stomach are rarely the seat of secondary tumours. On the other hand, the liver, lungs, kidneys, heart, skin, and bones are frequently the seat of such tumours. In some forms of cancer secondary tumours are peculiarly liable to form in the **Bone-marrow** in various parts of the skeleton. The brain is comparatively seldom affected either with primary or secondary cancers. Perhaps of all organs the liver is most liable to secondary developmen cancer. As it receives blood from the systemic as well as from portal circulation it may be infected, whatever the seat of the prin tumour.

There are some apparent anomalies in the distribution of cancers to the liver the lungs respectively. Thus a cancer of the lower end of the œsophagus will c give rise to secondary tumours in the liver, while a cancer of the stomach

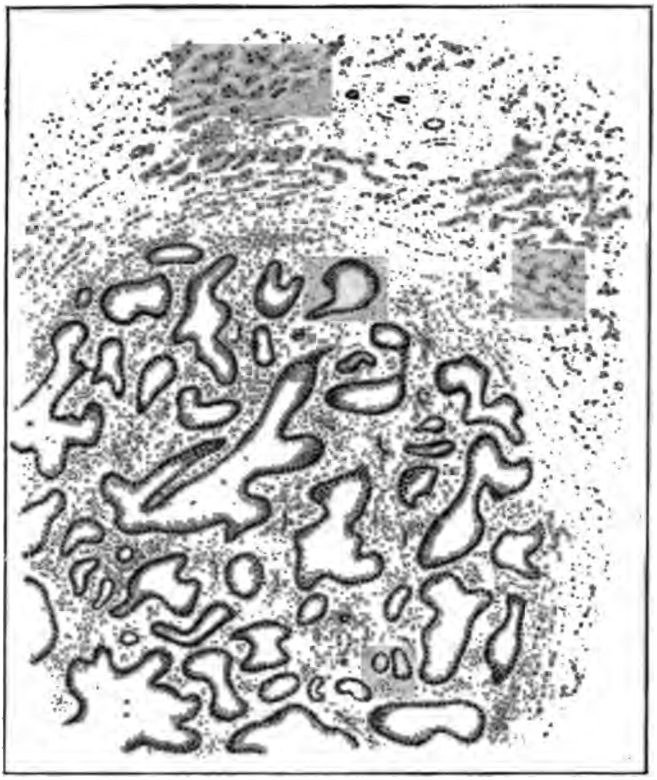

Fig. 188.—Secondary cylinder-celled epithelioma of liver. The primary growth was in the stomach. × 50.

give rise to tumours in the lungs. The author believes that this depends ch on the relations of the lymphatic glands from which the infection of the l occurs. In a case of cancer of the œsophagus observed by the author, he f that extension had occurred first to the lymphatic glands beneath the diaph and thence to the liver. On the other hand, in a case in which primary canc the stomach gave rise to tumours in the lungs, he found that the pre-vert glands were affected and that extension had occurred (as evidenced by the o rence of thrombi) to the vena cava.

The secondary tumours are often **more favourably situated for growth** than the primary one. They may be better supplied with blood and less exposed to mechanical or other interference. Hence they often grow to a much larger size than the primary one, and may show the structure more fully developed. Thus the liver is often the seat of bulky tumours, while the primary tumour is quite insignificant.

In their structure the secondary tumours **imitate the primary one** even in the finer details. This applies not only to the shape and size of the epithelial cells, but to the abundance and arrangement of the stroma, and even of the vessels in the stroma. If the stroma be abundant and fibrous in the primary tumour, it will show, at least, a tendency in the same direction in the secondary ones, although time may have failed to allow of the full manifestation of this.

This imitation of the primary growth produces very remarkable results. One sees, for instance, sometimes a tissue consisting of gland-like spaces, lined with cylindrical cells, growing abundantly in the liver (see Fig. 188), or lung, or brain. A striking illustration of this mimicry was found by the author in a case where a cancer of the stomach showed a striking tendency to hæmorrhage; the patient actually died from the effects of a large hæmatemesis. There were numerous secondary tumours in the liver, which looked almost like masses of blood. The delicate character of the vessels had been repeated in the secondary tumours, and bleeding was characteristic of them as well as of the primary growth.

Retrograde changes in cancers.—The cancerous tissue is much more prone to degenerations and secondary changes than is normal tissue. **Fatty degeneration** is very frequent. (See Fig. 189.) This may, in quickly growing tumours, affect considerable portions, so as to give rise to an appearance like caseation. In more chronic cases, the fatty degeneration affects more the individual cells. The degenerated cells are readily absorbed, and this often leads to a relative preponderance of the stroma. Thus cancers frequently shrink and become cicatricial in their older or central parts. This may lead to dimpling of the surface of a tumour, as we often see in cancers of the liver, producing the so-called **Umbilication. Mucous** and **Colloid degeneration** are not infrequent in cancers. They occur to a minor degree in many cancers of the intestine, but in a higher degree they are so characteristic as to give a special name to a form of cancer. (See Colloid cancer.)

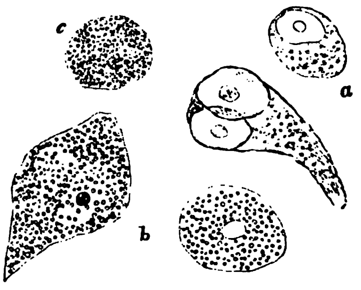

Fig. 189.—Fatty degeneration of the cells in a cancer of the mamma: *a*, slightly affected; *b*, more so; *c*, completely fatty. × 350.

Ulceration is the usual result in superficial cancers. As a rule the cancerous ulcer is bounded by a prominent border, co of tissue infiltrated wi growing tumour. (Se 190 and 191.)

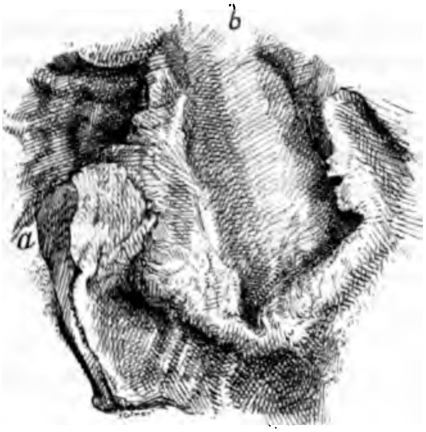

Fig. 190.—Ulcerated cancer of stomach. The central depression of the ulcer and the prominent infiltrated border are shown.

The local nature of —From what has been above, it will appea cancer begins as a local of epithelium, accompa the formation of a con tissue stroma of varyin plexity. It is in many well-formed but atypical In the secondary extens other tumours bear finite material relation primary one. They a the implantation of first, as a rule, in the lymphatic glands, and secondly, it may parts further removed. As the primary cancer sends of amongst the tissues, and extends outwards to the lymphatic

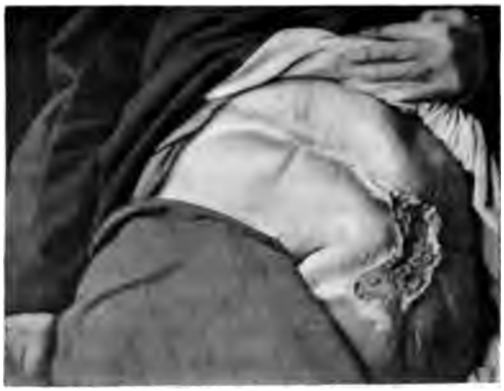

Fig. 191.—Epithelioma originating in the scar of a burn.

it usually is difficult to determine its limits, but if these can be determined, and the whole growth removed, then we infer that the disease will be eradicated. It is rare to fin primary cancers in the same person. In the great majority of all the existing tumours are direct descendants of a single primary growth.

The individual forms of cancer.—Various modes of classification have been adopted. That which we use here is not entirely satisfactory, but it is useful for practical purposes.

1. **Flat-celled epithelioma; Epithelioma proper.**—In English works the term Epithelioma is chiefly used to designate cancers of the cutaneous surface, lip, tongue, and œsophagus, places where the surface is covered with flat epithelium. Similar tumours occur in the larynx, uterus, vagina, and urinary bladder. It is possible to distinguish a penetrating or infiltrating form, and a more superficial form. This latter form is almost equivalent to the Rodent ulcer of English authors, and the *Flacher Krebs* of Thiersch and German authors.

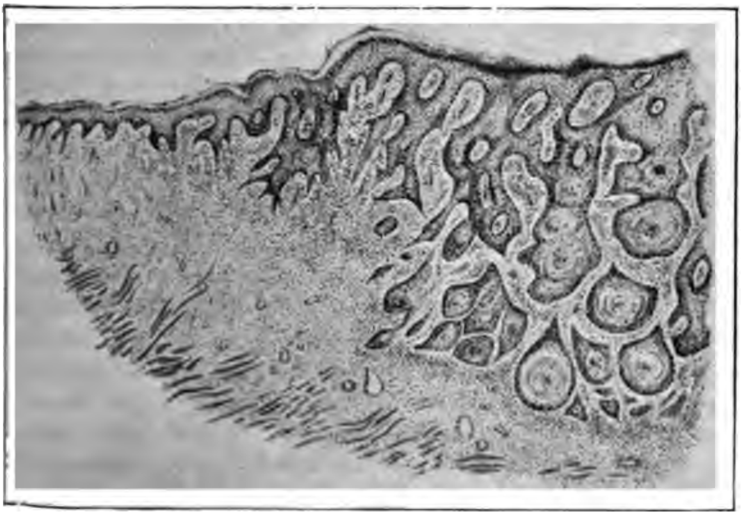

Fig. 192. Flat-celled epithelioma of lower lip. The invasion of the deeper tissues by cylindrical processes of epithelium continuous with the normal epithelium is shown. Laminated capsules are seen in process of formation. In the vicinity of the growth there is round-celled infiltration. × 20.

The common epithelioma of the lip is the most familiar example of the **infiltrating form.** In this form cylindrical processes of epithelium taking origin in the surface epidermis (see Fig. 192), grow downwards into the true skin, infiltrating it and destroying its connective tissue. These processes, as they grow, exercise a concentric pressure on their own cells, and so produce closely-packed globular bodies, composed of epidermic cells, wrapped round each other. These bodies, variously called **Epidermic globes, Laminated capsules,** etc., are very characteristic of this form of epithelioma. They are, ever, occasionally found in other epithelial proliferations. The ce the globes are usually horny, and the consequent bright transl appearance, as well as the bright yellow colour in sections treated picric acid, attract the eye in microscopic sections. These pro are usually surrounded by a round-celled infiltration. Leucocytes often be seen insinuating themselves between the horny epitheli the laminated capsules and eventually disintegrating these struc Giant cells, playing the part of phagocytes, are frequently found i vicinity of the laminated capsules (Fig. 193). In some parts th

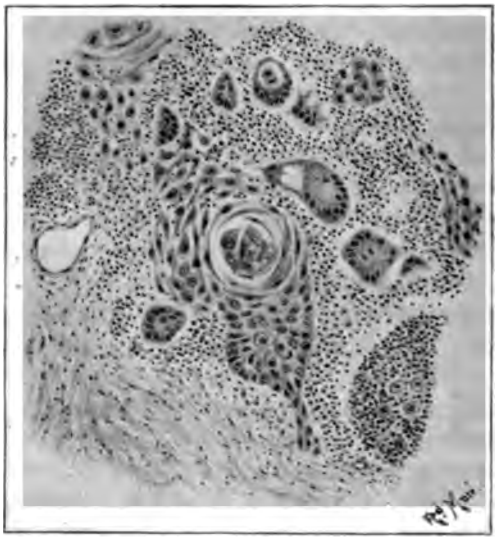

Fig. 193.—Epithelioma of lip. Leucocytes are seen invading an epithelial proces A number of giant cells are seen in the immediate vicinity. × 100.

along with the production of these penetrating processes, a form of papillæ on the surface. This is often manifest in the epithelio the scrotum and certain other parts of the skin. It is also pronounced in some of the vagino-uterine cancers, forming the so- **Cauliflower cancers.** In the urinary bladder there is freq such a marked production of elongated papillæ that the surf quite shaggy, while the mucous membrane beneath is infilt To this form the name **Villous cancer** is often given. The pa like those of the simple papilloma of the bladder, are lia hæmorrhage.

All these epitheliomas are prone to ulceration, and freq present themselves as ulcers with infiltrated walls.

Rodent ulcer is a special form of epithelioma which occurs in the upper part of the face, and more rarely in other parts of the body. The writer has met with it on the back and on the leg. It usually presents itself as an ulcer with overhanging edges, overhanging so much as to appear "rolled over." The edge shows the epithelial structures in the form of peculiar small epithelial cells arranged in well-defined groups (see Fig. 194), the peripheral cells of which are sometimes columnar. These groups of cells are beneath the epidermis, and seem in many cases to have no connection with the Malpighian layer. The tumour is a superficial one, there are no penetrating cylinders, no laminated capsules, and there is no tendency to invade the lymphatic glands. Its structure is best studied in very early cases where it appears as a small nodule under the epidermis.

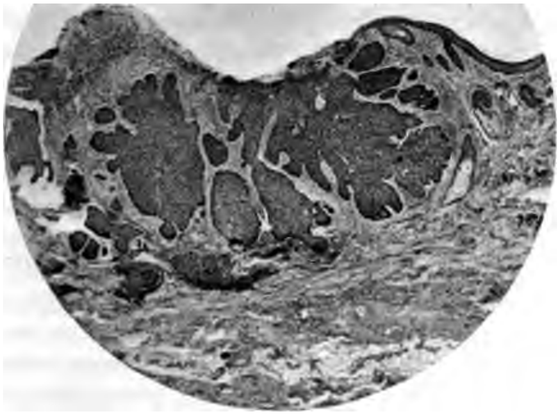

Fig. 194.—Rodent ulcer from the face. × 15.

The **Crateriform ulcer** of the face, described by Hutchinson, is an epithelioma. The name **Cholesteatoma** or **Pearl tumour** has been given to a form which is variously regarded as an epithelioma, an endothelioma, a cystic tumour, or a teratoma. It contains bright, glancing, pearl-like structures, consisting mainly of cholestearine crystals and fat. Besides these, there are flat cells, epithelial in character, which are arranged so as to form rounded bodies, inside which the cholestearine is contained. These tumours are sometimes surrounded by a capsule so as to resemble atheromatous cysts. They are most typically seen in the soft membranes and substance of the brain, but also occur in the subcutaneous tissue, testicle, ovary, parotid, and ear. (See Virchow, in Virch. Arch., viii.; Eberth, do., xlix.; Eppinger, Prag. Vierteljahrschr., 1875; Chiari, Cholesteato Rückenmarks, Prag. med. Wochenschr., 1883; Bristowe, Path. trans., 1854; Price, do., xxxviii., 24, 1887; and for more recent literature, Bo Lehre v. d. Geschwülsten, ii., 1902.)

2. Cylinder-celled epithelioma.—This is a tumour of parts

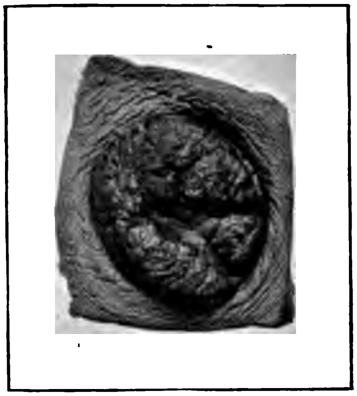

Fig. 195.—Cylinder-celled epithelioma of umbilicus.

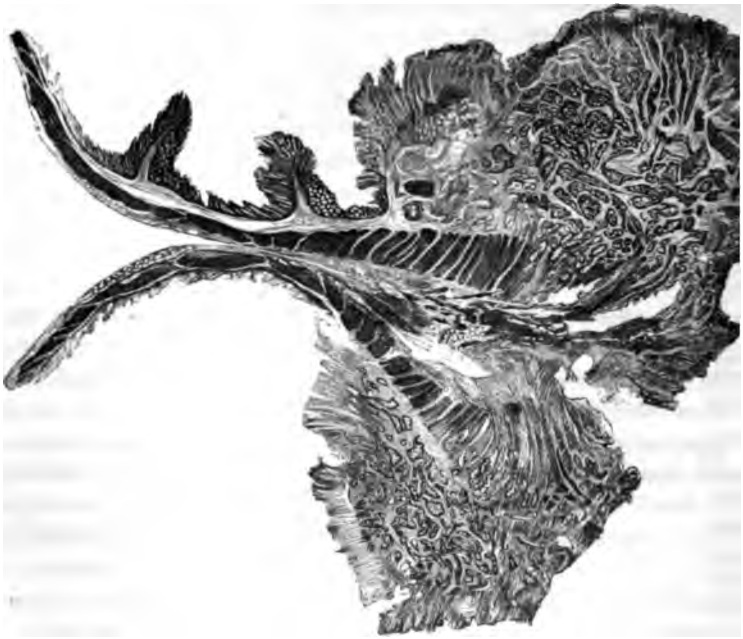

Fig. 196.—Primary cylinder-celled epithelioma of large intestine. The submucou tissue is infiltrated with variously shaped cancerous spaces. The muscular coa is also invaded at parts. × 15.

cylindrical epithelium normally covers the surface, hence it is found chiefly in the stomach and intestines, and more rarely in the uterus. As cancer of the stomach and intestine is of very frequent occurrence, this tumour, which is the most common form in these parts, is very often met with. The cylinder-celled epithelioma is one of the forms of cancer met with in the umbilicus (see Fig. 195).

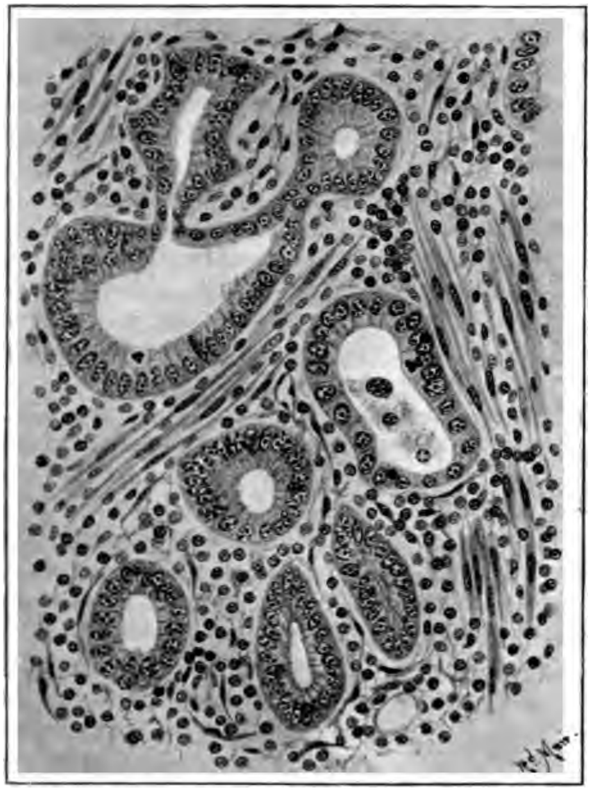

Fig. 197.—Primary cylinder-celled epithelioma of rectum. The growth invades the muscular coat. × 200.

The tumour usually takes origin in the mucous membrane or its glands, the chief exception to this being the case of certain rare tumours of the brain, where it seems to arise from the epithelial lining of the ventricles. The tissue has a glandular appearance, forming a congeries of tubes and cavities lined with cylindrical epithelium (see Figs. 196 and 197). Sometimes the glandular appearance is strictly preserved, but frequently the spaces enlarge, and as the epithelial cells accumulate they lose their cylindrical form, although the outer layer of cells next the stroma may still preserve the shape. glandular elements are contained in a well-formed stroma, wh is new-formed as well as the epithelial elements.

In growing, the tumour infiltrates neighbouring parts, very of insinuating itself among the muscular trabeculæ, and extend further. It may form a considerable tumour, projecting from

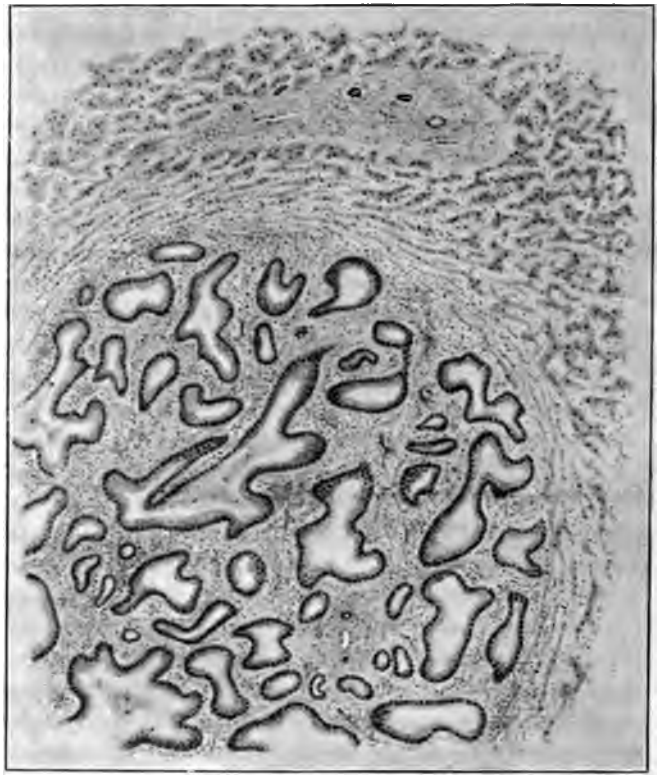

Fig. 198.—Secondary cylinder-celled epithelioma of liver. The primary growth was in the stomach. × 50.

surface, and is frequently ulcerated, as it occurs mostly in situat where it is exposed to friction. Secondary tumours closely resemb the primary are common (Fig. 198).

From the strikingly glandular character of these tumours, they included by some writers among the adenomas. They are called these writers **Malignant adenoma** or **Adenocarcinoma**. As they so distinctly atypical in their mode of growth, there seems no res to separate them from the cancers.

3. **Soft cancers, Medullary** or **Encephaloid cancers** are characterized by the existence of a very delicate stroma in which are abundant cells, sometimes of small size, loosely packed in the alveoli with a good deal of fluid (see Fig. 199). They occur chiefly on mucous membranes, in the ovaries, testicles, kidneys, less commonly in the mamma. Being soft, they tend to bleed, and if originating on a surface or coming to it in their growth, they may undergo ulceration. Sometimes the softened, ulcerating, bleeding tissue projects in a very striking manner from a surface, forming the **Fungus hæmatodes**, this condition also occurring, however, in soft sarcomas (p. 334). The cut surface of such tumours is grey in colour, and a somewhat fluid juice can be scraped from it. In this juice will be found cells and free nuclei, the latter large and mainly oval in shape. Many of the cells contain fat granules, and there may be some in an advanced state of fatty degeneration.

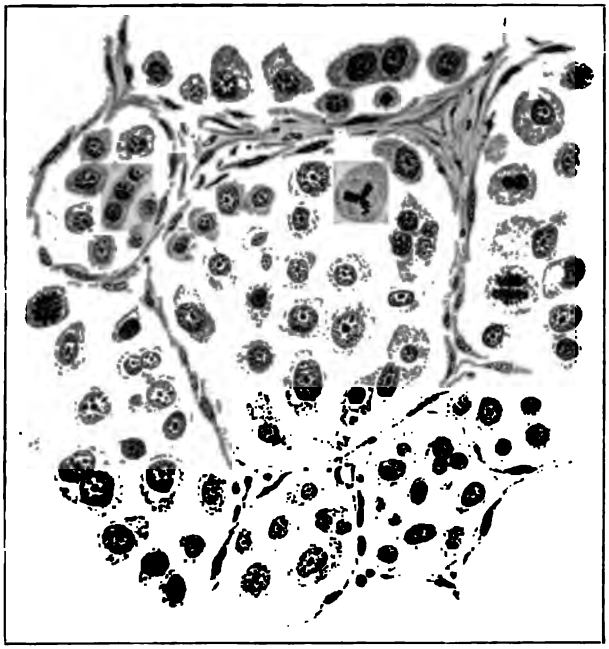

Fig. 199.—Soft cancer. From a secondary growth in the mesentery. The delicate stroma in the meshes of which cells of various forms are loosely arranged is shown. Notice the presence of mitotic figures. × 200.

Cancers of this kind sometimes grow to a considerable size, and they are often of very rapid growth. They are, as a rule, very malignant; the young cells, being loosely attached, readily pass away and lead to metastasis. Evidences of mitosis or nuclear division are commonly met with in the cells (see Fig. 199).

4. **Hard cancer** or **Scirrhus** occurs most commonly in the mamma, but also in the stomach, the testicles, ovary, pancreas, pleura, and peritoneum. It is characterized by the preponderance of connective tissue as compared with the epithelial structures. The cells in this form of cancer are mostly in narrow elongated processes divided by connective tissue which does not form a characteristic stroma (see Fig. 200).

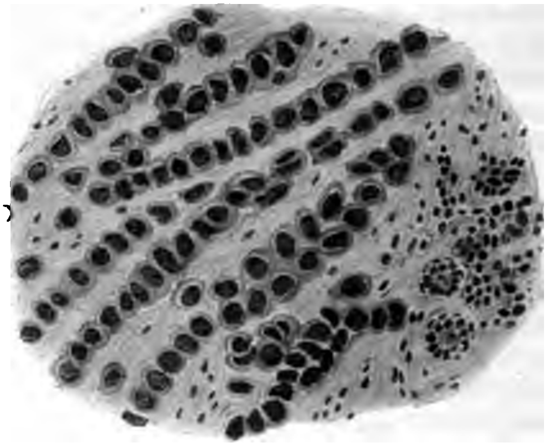

Fig. 200.—From a scirrhus of the mamma. The cell-masses of the cancer are in narrow elongated processes. To the right is some mammary gland tissue. × 80.

The cancers of this kind have usually a very infiltrating character, the epithelial processes penetrating among the surrounding structures, and it looks as if these processes, by their irritation, produced an excessive amount of connective tissue. This view is borne out by the fact that the connective tissue is not usually in the form of a well-developed stroma as if planned to support the epithelial structures, but is irregular and even impinges on and destroys the epithelial cells. The cells readily undergo fatty degeneration, and they sometimes to a large extent entirely disintegrate, the stroma assuming the upper hand. It therefore happens that different parts of such tumours have often very different characters. The more recent parts will show well-marked epithelial masses with stroma, while in the older parts the cells have almost disappeared, and there is nothing but dense connective tissue.

A scirrhus occurs more as an infiltration than a distinct tumour, the hardening and contraction of the connective tissue causes the organ in which it grows to be sometimes contracted rather than enlarged. It is frequently so in scirrhus of the mamma and of the stomach, its two most frequent seats. On cutting into the organ the tissue is felt to be dense and elastic. The cut surface is greyish and transparent, with opaque yellow markings indicating the existence of fatty degeneration in the cells. The juice to be obtained from the cut surface is scarce, and under the microscope it is seen to contain cells, often of large size, and free nuclei (see Fig. 201). The cells vary greatly in size and shape, and they often contain two nuclei, or even a fully formed cell inside (mother and daughter cells). These cells within cells are, however, frequently interpreted nowadays as the parasitic organisms of cancer.

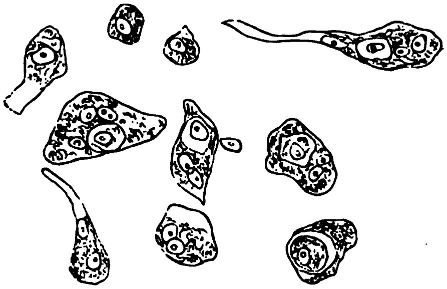

Fig. 201.—Cells from a cancer of the mamma. Most of them contain several nuclei. × 200.

These cancers are less malignant than the soft cancers, but they produce somewhat readily secondary tumours in lymphatic glands.

Between the hard and soft cancers there are cases presenting all shades of gradation; so that we might even speak of a group of simple or normal cancers. These have mostly a well-developed stroma with cells of moderate size which lie in the stroma in considerable spaces. The mamma presents these varieties, and they will be again referred to in the section devoted to the diseases of that organ.

5. **Colloid** or **Alveolar cancer** is a tumour characterized by the occurrence of colloid degeneration. It is met with chiefly in the stomach (Fig. 202) and intestines, and in the mamma (Fig. 203); more rarely elsewhere.

There is here a definite new-formation both of stroma and epithelial masses, and the stroma is often produced in most beautiful and characteristic forms (see Fig. 203). The cells regularly undergo colloid degeneration, as if it were in the plan of the growth, and finally the masses of cells become converted into masses of colloid material which fill the spaces. Allied changes probably occur in the stroma. In the bulk of the tumour therefore there may be nothing visible beyond the regularly formed stroma whose spaces are filled with clear transparent material. Occasionally there may be in the centres of the alveoli some remains of the cells visible, while the peripheral are already completely converted (see Fig. 203).

To the naked eye such tumours have a markedly gelatinous ap ance, and as the fibrous stroma may in its coarser meshes be vi without the microscope, it may, even to the naked eye, look there were nothing but alveoli filled with gelatinous material, l the name alveolar. The tissue is frequently dense and hard t touch. This arises from the fact that the alveoli are tensely p with the colloid material, and, the fibres being on the stretch, a resistance is offered, just as a tightly blown-up bladder is hard.

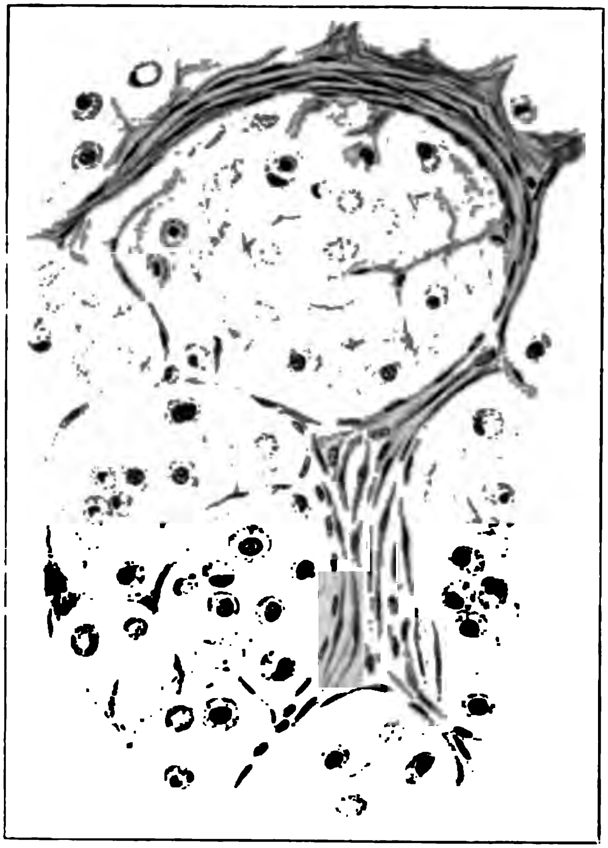

Fig. 202.—Colloid cancer of stomach × 300.

These tumours mostly occur as infiltrations, frequently penetr among the constituents of the tissues, and although they very extend widely by continuity (as in the stomach), they show little tendency to metastasis; even when they attack the lymphatic glands secondarily they do not usually produce large tumours.

6. **Melanotic cancer** is a rare form of tumour compared with the melanotic sarcoma. It occurs primarily in similar situations, namely the skin and eyeball. It is really a soft cancer in which pigment is present in the cells and also sometimes in the stroma. It is usually a very malignant tumour, producing secondary growths by metastasis.

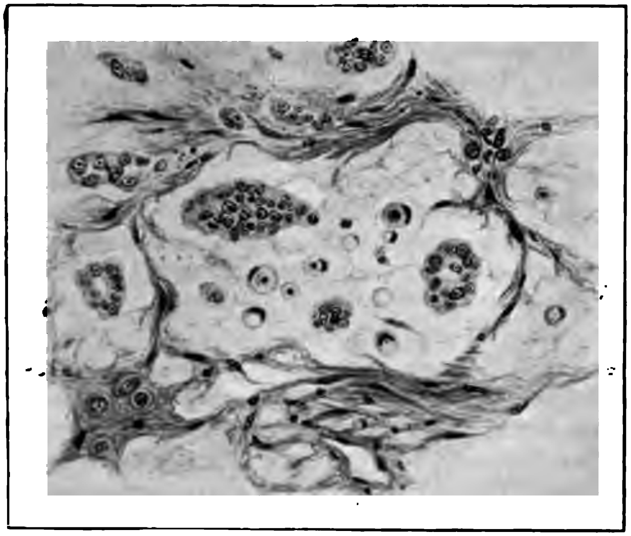

Fig. 203.—Colloid cancer of mamma. × 200.

7. **Mucous cancer** includes tumours in which the stroma of the cancer assumes the characters of mucous tissue. The cells of the cancer may undergo a similar degeneration. The tumour as a whole is very gelatinous in appearance, and is probably simply a form of the so-called colloid cancer.

8. **Endothelioma** is a name sometimes applied to atypical tumours arising from the endothelium of serous membranes and elsewhere. (See above.) Cancers of the pleura and peritoneum belong to this class. They will be described in connection with tumours of their own locality.

Deciduoma malignum is regarded by some as a form of cancer. (See under Generative Organs.)

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SECTION X.

RETROGRADE CHANGES.

I. **Necrosis, Gangrene, Mortification.** (1) Causes; direct injury, obstruction of arteries, spasm of arteries, obstruction of veins, nervous influences, assisted by weakness of the heart; (2) Forms of necrosis and changes in tissues, determined chiefly by inflammation and putrefactive changes. Various forms of gangrene; coagulation-necrosis; caseation; fat-necrosis; (3) Issues of necrosis. II. **Simple atrophy,** its physiological type. General and local atrophy. III. **Albuminous infiltration,** also in general and local forms. IV. **Fatty degeneration,** a transformation of nitrogenous principles. General and local forms. Character of lesion and results. V. **Fatty infiltration,** (1) in connective tissue, (2) in the liver. VI. **Pathological pigmentation**—Origin of pigment. (1) Alterations of physiological pigmentation; (2) pigmentation by hæmoglobin and its derivatives; (3) icterus, hepatogenous and hæmatogenous; (4) pigmentation in tumours; (5) pigmentation from without; (6) pigmentary atrophy. VII. **Amyloid degeneration**—Causation and nature of process; changes in tissues and seat; local amyloid degeneration; corpora amylacea. VIII. **Mucous, colloid, and hyaline degenerations.** IX. **Glycogenic infiltration.** X. **Calcareous infiltration,** mainly in dead or obsolete structures: characters and effects.

UNDER this designation are included a number of conditions, all of which imply a defect in the nutritive processes in the tissues. As the cells form the tissues, it is for the most part these which are at fault, although it may be that in some cases the most manifest visible changes are not in them. The most extreme case is where the nutrition ceases altogether, and the structure dies. Short of that, we have various lesions manifesting themselves. Thus there is a simple diminution of the vitality, and the structures dwindle. Again, the chemical constituents of the structures change, splitting up, it may be, into more elementary principles. Or the tissues are unable to prevent the deposition in them of extraneous material, which is thus infiltrated into them. These last are called infiltrations, whereas the conditions in which there is a degradation of the normal constituents into lower chemical substances are designated degenerations.

I.—NECROSIS: GANGRENE: MORTIFICATION.

The term **Necrosis** is equivalent to local death of tissue, and includes all forms of lesions in which any portion of the body loses its vitality. **Gangrene** has a more limited significance, being applied chiefly to cases in which the necrosis is accompanied by putrid decomposition of the part, and especially to death of considerable portions of the external parts of the body. **Mortification** has a similar meaning. **Sloughing** is the death and separation by ulceration of smaller parts of the soft external tissues. **Sphacelus** has a similar significance. Necrosis is sometimes used in the limited sense of death of bone or cartilage.

1. **Causes of necrosis.**—An agent may cause necrosis by acting directly on the tissues, or may do so indirectly by interfering with their blood-supply or innervation.

Instances of **Direct action** are afforded by chemical agents, by morbid poisons, by traumatic action, and by extremes of temperature.

Chemical agents, such as strong acids or alkalies, destroy the vitality of the tissues by their caustic action.

Toxins evolved by **microbes** frequently produce necrosis. The products of ordinary putrid decomposition may do so, as where decomposing urine is extravasated into the tissues. We see also in the case of pyæmia, erysipelas, tuberculosis, syphilis, diphtheria, that when microbes settle in the tissues and multiply, they commonly give rise to necrosis when acting in a concentrated form.

Traumatic action, besides its direct effect in injuring the tissues, produces necrosis by obstructing or rupturing the vessels.

Extremes of heat or cold produce necrosis, partly by affecting the living structures directly, and partly by their effect on the vessels. The ear of a rabbit, which has been ligatured at its base and immersed in water heated to 130°-136° F., or in a freezing mixture, reduced to about 0° F., suffers necrosis even when the immersion is for a very short time, and the ligature is removed at once. If the temperature is less extreme a short immersion produces intense inflammation, and a longer immersion produces necrosis (Cohnheim).

Pressure on a part produces necrosis when long continued, and i does so chiefly by emptying the vessels, and especially the capillaries. Pressure from within is exemplified in the case of abscesses an tumours which advance to the surface and cause sloughing of th skin. External pressure is seen to produce necrosis, in the case o bed-sores, or where bandages and splints, by pressing on a bon prominence, cause sloughing of the skin over it.

Obstruction of arteries is a frequent cause of necrosis. As the nutrition of the tissues depends on the capillary circulation, obstruction in an artery will scarcely produce necrosis, unless it brings about a complete stasis in the capillaries. (See under Embolism.)

Besides obstruction of arteries by embolism, there is very frequently a partial interference with their calibre as a result of atheroma, especially when thrombosis is superadded. In **senile gangrene** there is always atheroma of the arteries of the lower limb, and this, even without complete obstruction, may be the cause of gangrene, although weakness of the heart and of the tissues resulting from old age may contribute. **Softening of the brain** in old people is similarly produced by atheroma. These softenings are frequently in the cortex of the brain, and lead as much to weakness of mind as to motor paralysis, whereas softening from embolism is usually central, and leads to more definite paralysis.

Spasm of arteries is an occasional cause of gangrene, as in Raynaud's disease (see under Diseases of the Skin). It has also been assigned as the cause of gangrene in poisoning with **Ergot of** Rye. In former days there used to be epidemics of what is now recognized as Ergotism from eating bread made with grain in which ergot was present. The local symptoms usually consisted of disturbances of sensation, followed by redness of the skin, sometimes culminating in necrosis of the tips of the fingers and toes, or of the nose and ears. This result is ascribed by some to spasm of the arteries, a view which is confirmed by an observation of Recklinghausen, who found by experiment in fowls that under the influence of ergot the arterioles of the cock's comb and of the tongue showed a violent and persistent contraction, during which thrombosis occurred, obstructing or occluding their calibre. Besides this action on the vessels, the poison may have a directly poisonous effect on the tissues, and the necrosis may be further assisted by the injury to which an anæsthetic part is exposed.

Obstruction of veins seldom produces necrosis, as these vessels anastomose so freely that stasis in the capillaries will rarely occur. It takes place, however, when a piece of intestine is incarcerated in a sac with a narrow neck, as in a **strangulated hernia,** in which case gangrene is frequent. Extensive venous thrombosis even may lead to gangrene.

Nervous influences frequently contribute to the production of necrosis. Lesions of the peripheral nerves, the spinal cord and brain, are sometimes followed so rapidly by the formation of sloughs in parts of the body exposed to pressure in lying in bed, that the term **Acute bedsore,** or **Acute decubitus,** has been applied. This has been ascribed to an affection of the trophic nerves by the primary lesion, but it remains doubtful to what extent the immobility of the patient, his constant retention of the same posture, and the alteration in the circulation may account for the necrosis without calling in the action of trophic nerves.

A similar difficulty exists as to the necrosis in **Anæsthetic leprosy**. Here the affected parts are devoid of feeling and the vaso-motor nerves are implicated, hence the parts are more exposed to injury and to variations in temperature, which are not compensated by alterations in the circulation.

In all the forms of necrosis **Weakness of the heart** may exercise an influence, and in some cases it may even be the main element. In extreme cases of general weakness, and in some cases of specific fever, there may be necrosis of the extremities partly due to weakness of the heart and partly to alteration in the constitution of the blood.

The various tissues comport themselves somewhat differently in relation to the causes of necrosis, or, in other words, they are able to survive in different degrees a deprivation of blood. For example, Litten found that if he ligatured the renal artery in a rabbit for 1½ to 2 hours and then removed the ligature, the circulation was perfectly restored, and the blood-vessels and connective tissue survived; while the epithelium of most of the convoluted tubules underwent necrosis. Ehrlich and Brieger found that a suspension for one hour of the circulation in the lumbar part of the spinal cord caused necrosis of the grey substance, while the white substance was not affected. Muscle seems also peculiarly sensitive to deprivation of blood. Thus in embolism of the coronary artery of the heart the muscular fibres die before the circulation can be re-established, while the connective tissue survives. In this relation, skin, bone, and connective tissue possess great powers of resistance, while nervous tissue, muscle, and the secreting tissue of glands are more vulnerable.

The tissues again may be rendered unduly susceptible of necrosis. Anæmia and passive hyperæmia render the tissues more vulnerable. Diabetes has a similar effect; boils and carbuncles are common in that disease, and slight injuries are liable to go on to necrosis. Again, children who are in extreme states of inanition, especially after acute fevers, are liable to **Cancrum oris** or **Noma** in which extensive necrosis of the soft parts in the neighbourhood of the mouth occurs.

2. **Forms of necrosis, and changes in the tissues.**—The changes which the dead tissues undergo vary considerably according to circumstances, and the resulting appearances are so different that special names are given and special forms described according to the appearances presented. From what has gone before, it will appear that **inflammation** frequently goes along with necrosis; the two are sometimes produced simultaneously by the same cause, or the dead structures may in themselves, or by the products evolved by them, produce inflammation.

The circumstances which determine the form which the necrosis will assume are chiefly these—the position of the dead structure, whether internal or external, whether protected from the access of microbes or not; the presence or absence of acute inflammation; the bulk of the dead piece; its structure and chemical constitution. The most important circumstance is whether **putrefactive changes** occur or not. Dead pieces of tissue, like all dead animal matter, are liable to decomposition under the influence of microbes. In most cases of

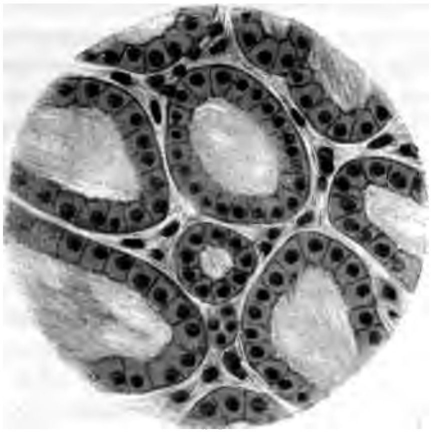


Fig. 204.—Section of normal part of kidney. The nuclei of the epithelium of the tubules brought out by staining.

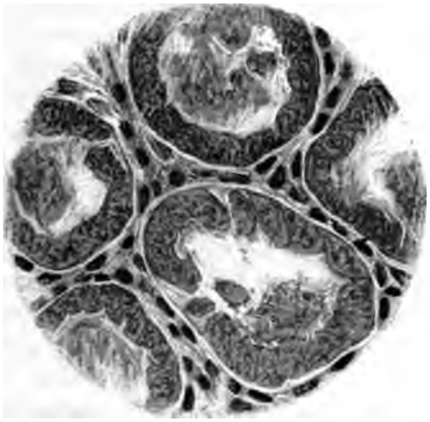


Fig. 205.—Section of affected part of same kidney near border of infarction. The tubular epithelium necrosed, the nuclei invisible. The interstitial tissue with many nuclei.

necrosis in external parts and in the lungs, the air findin carries with it the microbes concerned in these processes, an faction is the result. In this case the term gangrene is applied.

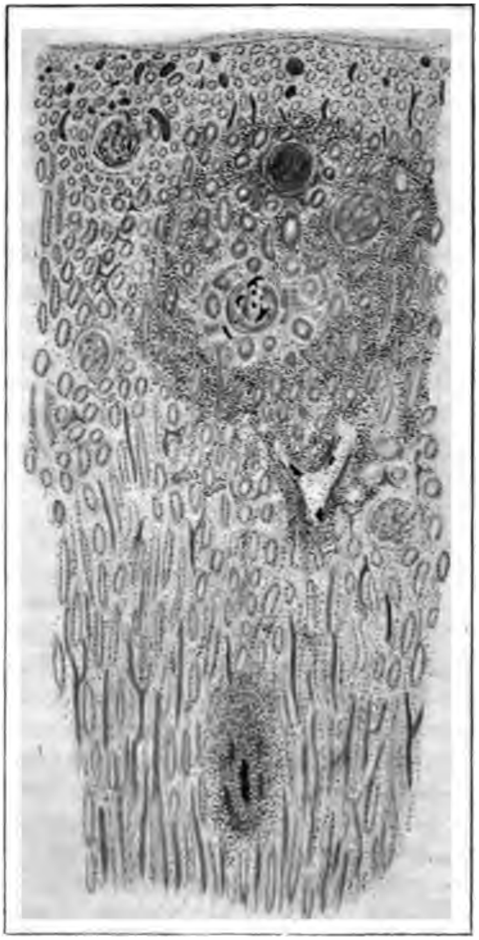


Fig. 203.—Necrosis of renal epithelium from microbic embolism. × 40.

In most cases of necrosis the process is characterized by **appearance of the nuclei of the cells.** Figs. 204 and 205 sho the case of necrosis from embolism in the kidney. Fig. 204 is tissue outside the necrosed area, and it is seen that the nuclei the connective tissue and epithelium are preserved. Fig. 20 *other* hand, is from the infarction near its outer limits; here t have disappeared from the epithelium, but are preserved in the connective tissue.

In Fig. 206 there is also disappearance of the nuclei of the renal epithelium in consequence of the presence of microbes in a capillary blood-vessel. This is probably from necrosis as a result of the action of the microbes, but as putrefaction also leads to disappearance of the nuclei, it may be an effect of the post-mortem growth of microbes, which however must have been planted during life.

a. **Dry gangrene or Mummification.**—These terms are applied in the case of external parts, when the circumstances are such that there is little moisture in the parts. Hence it will not occur where acute inflammation precedes or accompanies the process. It is mostly met with in cases of embolism or other obstruction of the arteries, and is characteristic of senile gangrene and of Raynaud's disease. The part undergoes a gradual deepening of colour; at first merely livid, it passes into purple, deep blue, and even black. This is due to the fact that the blood-pigment is dissolved out and stains the tissues, which deepen in colour as the pigment becomes concentrated by the part drying. The cuticle generally gets raised by the accumulation of a red fluid beneath it, and bullæ are formed. If the cuticle separates, evaporation is accelerated. The part, which is usually the extremity of the lower limb, gradually shrinks, and is converted into a hard black mass (see Fig. 207), often with a mouldy smell. In dry gangrene there is putrid decomposition, but as there is a deficiency of fluid this occurs to a subordinate degree.

b. **Moist gangrene, Sphacelus, Sloughing.**—In the conditions designated by these names, putrid decomposition plays a prominent part, and the tissues are separated in a softened condition. Moist or ordinary gangrene is the condition where a considerable portion of the body has died and is undergoing separation. It is well seen in cases where a portion of the leg has died in consequence of injury. The parts which were at first hot, red, and painful, become mottled with brown, blue, and black, and the surface often presents blisters. The part becomes cold and darker except at the margin, where a dusky red line of demarcating inflammation appears. The tissues are universally stained with blood-pigment, the cuticle gives way, and putrescence advances, causing breaking down of the tissues, which are separated in all stages of softening, the more resistant tissues such as bone and cartilage retaining their form. The part exhales a strong odour, and its juices contain fluid fat, phosphates, extractives, as well as multitudes of microbes. The appearances of gangrene supervening on frost-bite are similar (see Fig. 208).

Sloughing is a similar process where smaller parts of the s
are separated in a state of putrid decomposition.

c. **Desiccation without putrescence.**—This is somewhat
dry gangrene, except that, occurring in internal parts, th

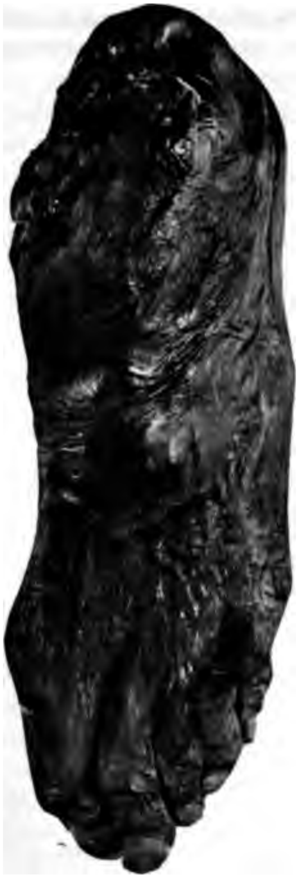


Fig. 207.—Dry gangrene of the foot.

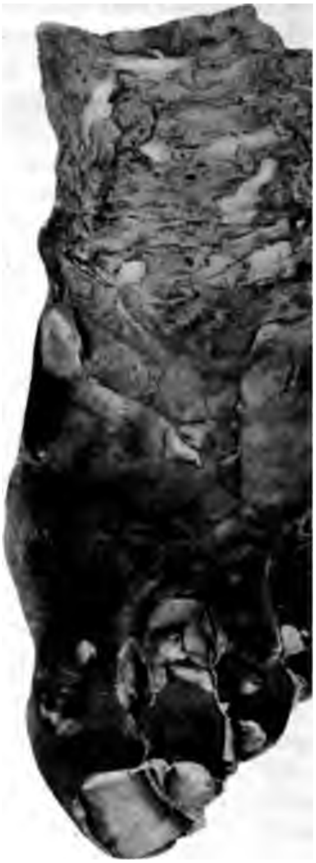


Fig. 208.—Gangrene of the foot followin

decomposition. The part simply dries in and shrivels.
striking example of this is afforded by extra-uterine preg
which the fœtus after its death is retained in the abdom
mother. The fœtus may remain for many years, simply dryi
getting encased in a capsule, which becomes impregnated
salts. Virchow in a case of this kind found muscle, connecti
and vessels still recognizable after twenty years. In twin pr
also, one of the fœtuses may die at an early period, but, being

it is born along with the other in the form of a dry flattened object (*Fœtus compressus*).

d. **Softening without putrescence, Colliquefaction.**—This is almost peculiar to necrosis of the nervous system in consequence of obstruction of arteries. The process is accompanied by fatty degeneration.

e. **Coagulation-necrosis.**—This term was introduced by Cohnheim, and the subject has been elaborated by Weigert. When necrosis occurs in internal parts which are rich in cells, then the tissue frequently becomes converted into a solid, firmly compacted mass. Weigert compares the process to the coagulation of the blood, and asserts that the cells in dying enter into combination with the fibrinogen contained in the fluid which permeates the tissue. In order that this process may occur the tissue must be a very cellular one, and an abundant supply of fluid must be present. The embolic infarction in the spleen and kidney forms the most typical example. The infarction forms a stiff, firm wedge which may be pale or may contain blood (see Fig. 209). The process is characterized by the disappearance of the nuclei from the affected structures.

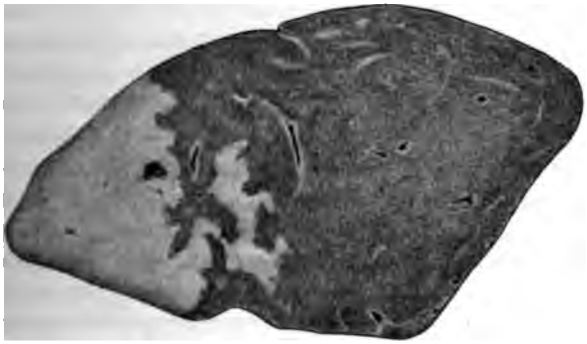


Fig. 209.—Section through an infarction of the spleen. The pale wedge-shaped infarction contrasts with the dark splenic tissue.

A peculiar change which occurs in voluntary muscle is also regarded by Weigert and others as a form of coagulation-necrosis. This is the process described by Zenker as **waxy degeneration of muscle,** which is also designated colloid and **hyaline degeneration.** It is brought about by direct injury to the living muscle. It also occurs in certain febrile states where the temperature runs high, especially in typhoid fever and phthisis pulmonalis, and is sometimes seen in paralyzed muscles. It may be produced artificially in a living animal by freezing the muscle, or immediately after death, by injuring the muscle before the occurrence of post-mortem rigidity. The change is met with, in the human subject, chiefly in the diaphragm, the rectus abdominis, the adductors of the arms. In consists in a coagulation of the tractile substance, the fibre being converted into a homogei translucent cylinder. The affected fibres are brittle, and the cylii get broken up, often presenting transverse cleavages, or giving c to oval clumps, as in Fig. 210.

In **atheroma** of arteries there are often translucent structui pieces in the walls, which Weigert also claims as exampl coagulation-necrosis. Similarly some tube-casts in the kidney supposed to originate by necrosis and coagulation of the epitheliur

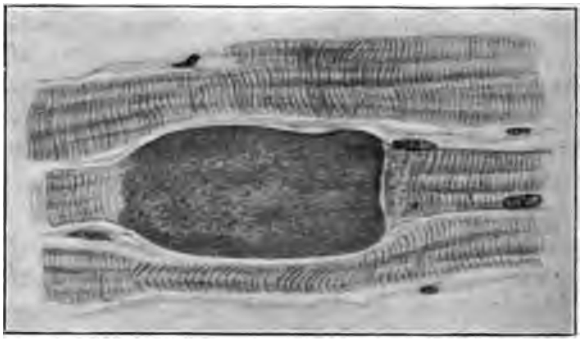


Fig. 210.—Hyaline degeneration of muscle. × 200.

Hyaline degeneration, as used by Recklinghausen, to a large e covers the same ground as the coagulation-necrosis of Cohnhein Weigert. (See further on.)

f. **Caseous necrosis.**—This is a condition closely allied to coa tion-necrosis. In the latter the necrosis occurs for the most suddenly in structures hitherto unaltered, whereas caseous necrc always part of another pathological process. It is highly characte of tuberculosis, so much so that the term is nearly equivalent t older designation tuberculization, and caseous matter is virtuall same as **crude** or **yellow tubercle.** It is also frequent in sypl new-formations. In all cases there is a great abundance of cells, are not the normal cells, but are produced by exudation or formation. The necrosed tissue undergoes a process of condens or coagulation, accompanied by fatty degeneration, the result be somewhat dense brittle matter, which has been compared to chees

In its microscopic details the process involves a complete obscui of structure. The nuclei disappear as in coagulation-necrosis, an presence of abundant fine fat granules renders the structure opaque and homogeneous. As the necrosis involves not only the new-formed cells, but the tissue in which they are seated, the result is a disappearance of the details of the tissue, sometimes to such an extent as to render the structure difficult of identification.

g. **Molecular necrosis.**—This term is used chiefly in regard to lesions of a surface in which there is a gradual extension of necrosis, and the dead structures are removed in a finely disintegrated condition without solid sloughing. The result of this is the formation of an ulcer, and as there is a gradual extension of the necrosis there is usually a progressive **Ulceration.** The process is usually the result of infective agents. Thus tuberculosis of a mucous surface produces a progressive ulceration by necrosis of the tissue and gradual removal of the dead tissue. The necrosis here, as mentioned above, is caseous necrosis.

h. **Fat necrosis.**—Opaque whitish-yellow, sometimes calcified, patches are frequently met with in the adipose tissue of the abdomen in the vicinity of, and in association with, certain diseases of the pancreas. (See Pancreas.) In the affected parts the fat is represented by fine crystalline aggregations or by granular detritus. The condition has given rise to much discussion, but is by most observers regarded as due to the escape of the fat-splitting ferment of the pancreas and the union of the resulting fatty acids with lime salts. It can readily be induced experimentally.

3. **The issues of necrosis.**—In many cases **the necrosis limits itself** at once, the agent which produced it having acted once for all. It only remains to dispose of the dead structures. In other cases the limitation does not take place so directly, and the formation of a **line of demarcation** is anxiously looked for. This is frequently the case in traumatic necrosis where it may for some time be doubtful to what extent the tissues have been injured beyond recovery. The co-existence of inflammation, especially when this is associated with decomposition, often renders the limitation of the necrosis more difficult. In infective processes also, such as tuberculosis, the necrosis follows the advance of the lesion. Again in senile gangrene, where the arteries are seriously obstructed, the starting point of the necrosis may be a trivial injury, and its progressive extension may go on without any signs of limitation for a considerable time.

In the **disposal of the dead tissue** inflammation plays a most important part. We have seen that violent inflammation is often produced by the same cause as the necrosis, or may supervene on it. This will mostly be the case in external parts where decomposition occurs. The inflammation is characterized by hyperæmia and exudation, and commonly goes on to suppuration. A layer of pus come thus to divide the dead tissue from the living, and the dead is ca off as a slough. There remains a suppurating wound or ulcer.

In internal parts, if the necrosis be accompanied or followed by th production of irritating chemical substances, then a violent inflamm tion will be produced around. It is so in the case of pyæmia, whe there is septic embolism. In this case the inflammation will usuall be violent enough to produce suppuration, and the result will be th formation of an abscess.

In the case of internal parts where there is no disturbing decon position, or in external parts which are protected from septic contam nation, the inflammation is of a much milder character. The necrose portion now comes to act as a foreign body or dead piece of tissue and is subject to the changes already described. The dead tissu is often eaten into and replaced by vascular granulations, whic finally contract and leave a small residue of connective tissue; or th dead piece is encapsuled and may lie quiescent. Not infrequently th encapsuled tissue undergoes infiltration with lime salts, as we shall se presently. In the case of necrosis in bone the external capsule frequently composed of new-formed bone.

Literature.—CARSWELL, Elementary forms of disease, Art. Mortification, 183 VIRCHOW, Handb. d. spec. Path., vol. i.; PAGET, Lect. on surg. path., p. 34 COHNHEIM, Allg. Path., vol. i., p. 526, and Die embol. Proc.; RECKLINGHAUSE Allg. Path.; LITTEN, Zeitsch. f. klin. Med., vol. i.; KOCH, Traumatic infecti diseases (Syd. Soc. transl.); BURDON SANDERSON, Path. Trans., xxiii., Brit. Me Jour., 1877; WEIGERT, Coagulation-necrosis, Virch. Arch., lxxix., p. 89; CHAUVEA Nékrobiose et Gangrène, Bullet. de l'Acad. de Méd., 1873; FITZ, Fat necrosis, Allbutt's Syst. of Med., iv., 1897; OPIE (with literature), Johns Hopkins Hos Reports, ix., p. 859.

II.—SIMPLE ATROPHY.

By this term is meant a simple diminution in the nutritive activit of the structures, and a consequent diminution in size without furth change. Strictly speaking, we should distinguish from this a sma ness due to defective growth, to which the terms **Hypoplasia** ar **Aplasia** are applied. But atrophy is frequently used so as to incluc both conditions.

Physiological atrophy.—There are certain normal processes of dec which occur in the body. At certain periods, for instance, the mi teeth drop out, and this is effected by an atrophy of the fang that the crown is shed. At a still earlier period the thymus glar atrophies. Then again throughout life there is a continual sheddi of the hair. If a cast-off hair from the eyelash be examined under the microscope, it will be seen that its bulb is atrophied, and this is the cause of its being shed. In some persons the hair of the scalp is largely shed at a comparatively early age, without being properly reproduced, there being here an atrophy of the hair-sheaths and papillae. Then there is the normal atrophy of the tissues generally, which occurs in old age. The atrophy of old people is in many cases due to some organic disease, the symptoms of which are not manifest; but we are all familiar with the healthy old person with shrivelled hands and face and plicated skin.

In all these cases there is a kind of intention in the tissues, so to speak, according to which they live a certain period and then decay. As Paget has pointed out, such atrophies may almost be regarded as active processes. The fall of the leaf is due to an active absorption or atrophy of the fibres uniting it to the stem; if the leaf dies before its time, or is killed, it remains hanging, but in the natural course it drops when its time is come. So with our tissues and the whole organism; there is a limit to their activity. The period varies in different persons, and in this respect hereditary influences have an important bearing. Just as these largely determine the period of growth of the body and its rapidity, so they influence the duration of activity of the tissues. This is plainly seen in the case of the hair; baldness runs in families, just as longevity does.

Causation and Forms of atrophy.—Atrophy in many cases depends on some interference with the supply or alteration in the quality of the nutritious material supplied to the tissues. It is also related frequently to diminution in the function of the parts, while in some cases it depends more directly on interference with the nervous arrangements.

General emaciation indicates that the tissues generally have been affected in such a way that their nutrition is diminished. This will occur as the result of an alteration in the blood. The blood, being the vehicle for the conveyance of nutriment to the tissues, may be impoverished because of a direct interference with the food-supply, as in starvation, in stricture of the œsophagus, excessive vomiting, diarrhœa, etc.; or there may be an excessive consumption of the nutritious material, in cases of excessive discharges, as in phthisis pulmonalis, or ulcerating cancers; or there may be, as in fevers, an increased consumption of the nitrogenous elements of the tissues.

In general emaciation the various constituents of the tissues do not atrophy in an equal degree. According to experiments by Chossat, in which animals were deprived of food, the fat and blood diminished most, next to them came the muscles and the abdominal glands, while the bones and central nervous system diminished least.

Senile atrophy is closely related to the physiological atrophies already mentioned. The atrophy of some tissues in old age renders them more liable to pathological processes. Thus the bones, being diminished in size, and having proportionately less animal matrix, are more liable to fracture; and the lungs, having lost their supporting tissue, are more liable to emphysema (senile emphysema). "Brown atrophy" of the heart is seen in the aged as well as in the subjects of chronic diseases. (See under Heart.) The brain also undergoes atrophy in old people, and the kidneys frequently do so.

Atrophy from disuse manifests itself chiefly in the muscles and glands. When a joint is disused from being rendered rigid by disease or from paralysis, the muscles undergo atrophy, and even the bones diminish if the condition be prolonged.

Atrophy from pressure is exemplified in the atrophy which occurs as a consequence of the advance of tumours and aneurysms, or external pressure from stays, etc. In the last-mentioned case the liver frequently suffers considerable atrophy. Atrophy is also not uncommon in organs which are the seat of interstitial inflammation, the new-formed connective tissue causing atrophy by its direct pressure on the proper tissue, or by obstructing the blood-vessels.

Atrophy from nervous lesions.—This is a somewhat wide subject, and will be more fully considered in the special part of this work. In ordinary motor paralysis there is atrophy from disuse. But there are atrophies of a more active kind following lesions of nerves and of the spinal cord which are referred to interference with the trophic nerves or centres. These include atrophy of the nerve-fibres and of the muscles. According to Charcot a muscle or nerve atrophies when cut off from its trophic centre, and this may be effected by interruption of the conductivity of nerve-fibres, or by destruction of the centre. The atrophy of the muscles in **lead-palsy** belongs to this class.

Hemiatrophy of the face belongs to the class of neurotic atrophies. It affects the soft parts of one half of the face and of the tongue, while the bones are not affected unless the disease has occurred in early life, and even then the bones are unequally affected. The lesion is probably due to interference with the nerves, perhaps in their passage through the cranium or at their ganglia. A **hemiatrophy of the body** sometimes occurs from cerebral lesions in the fœtus or young child. This may be in the form of a crossed hemiatrophy, the face and extremities being affected on opposite sides.

In the various forms of atrophy, with the exception of general emaciation, the proper functionating tissue is that which chiefly suffers diminution. Thus in muscles it is the contractile substance, in glands the secreting cells, in nerves the nerve-fibres, which are specially affected. The atrophy of the proper tissue is often accompanied by **new-formation in the accessory structures.** Thus, atrophy of muscle is often associated with increase of the interstitial connective tissue. This connective tissue frequently becomes the seat of fatty infiltration, so that adipose tissue largely replaces the muscle, bringing about a pseudo-hypertrophy. (See under Hypertrophy and Fatty Infiltration.) A similar process frequently occurs in and around disused glands.

Literature.—Paget, Surgical Path., 3rd ed., p. 69; Recklinghausen (Neurotic atrophy), Allg. Path., p. 326; Charcot, Senile diseases (Syd. Soc. trans.), 1877, Dis. of nerv. syst. (Syd. Soc. trans.), 1881; Chossat, Rech. exp. sur l'inanition, 1843; Mühlmann (literature), Changes in the body in development and senility, Wiesbaden, 1900.

III.—ALBUMINOUS INFILTRATION—CLOUDY SWELLING.

The condition designated by these terms was first described by Virchow, and regarded by him as characteristic of **Parenchymatous inflammation.**

It is possible to distinguish a local from a general cloudy swelling. The **local form** occurs in parenchymatous inflammation, more especially of the kidneys, and is sometimes the most pronounced evidence obtainable post mortem of the existence of that condition. The **general form** occurs in most febrile diseases and is very characteristic of some. It is met with in the specific fevers, in erysipelas, diphtheria, acute phthisis pulmonalis, etc., and seems to be related in these cases to the high temperature and the altered state of the blood. It also occurs as one of the results in certain cases of acute poisoning. In the general form the lesion is diffused through various organs, but affects especially the liver (Fig. 211), kidneys (Figs. 212 and 213), heart, and voluntary muscles.

In these various cases the condition seems to be due to an irritation of the cells, which are induced to absorb more albumen than they can assimilate. The cells are enlarged, and they are clouded with albuminous granules, which obscure the nuclei. The condition implies a qualitative defect in the cells, although quantitatively there is excess. The defect is further shown by the co-existence of a minor degree of fatty degeneration (see Fig. 213). The fine fat granules may be obscured by the albuminous granules, but if the albumen

be dissolved by adding liquor potassæ, or a dilute mineral aci
fat comes out very prominently.

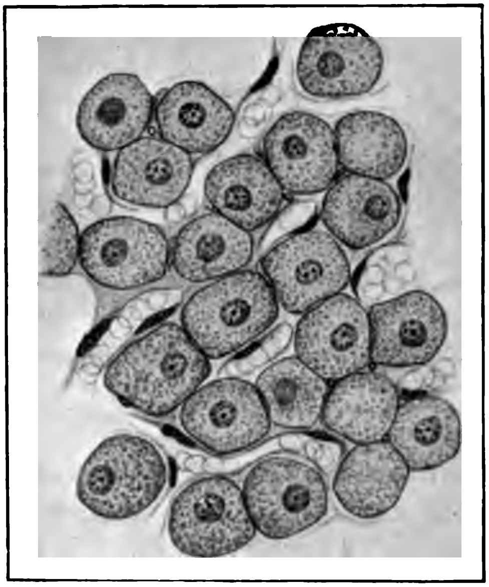


Fig. 211.—Cloudy swelling of the liver. From a case of acute pneumonia. × 50

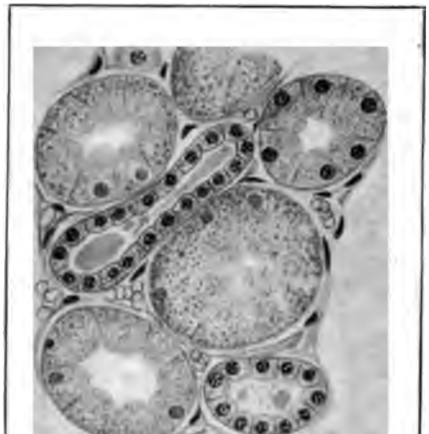


Fig. 212.—Cloudy swelling of the kidney. From a case of typhoid fever. × 200

The organs affected have, to the naked eye, a characteristic a
ance. They are enlarged, sometimes to a high degree, and ha

section, a bulky appearance, while the tissue has a grey, opaque, dull or blurred character. In acute fevers the enlargement of the liver and kidneys is sometimes very great.

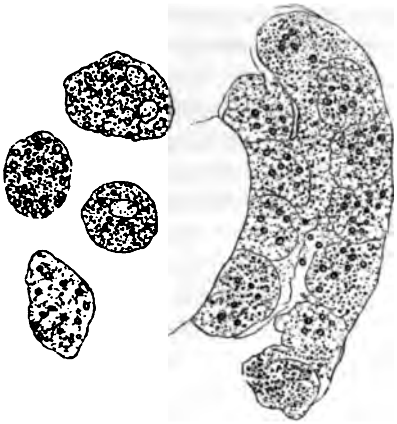


Fig. 213.—Cloudy swelling of renal epithelium with slight fatty degeneration as seen in the fresh state. A portion of a tubule is shown, and some isolated cells. x 350.

Literature.—Virchow, Cellular Pathology, transl. by Chance, also various papers in his Archiv.; Benario, Die Lehre v.d. trüben Schwellung, Würzburg, 1891; Verworn, Pflüger's Arch., 63, 1896.

IV.—FATTY DEGENERATION.

In this condition, which affects the cells of tissues, there is a change in the chemical composition of the cell-contents; the albuminous constituents split up and yield fat.

Causation.—Fat may be formed in the animal body either from the carbo-hydrates or albuminous substances of the food. In the case of fatty degeneration the fat is derived from the albuminous constituents of the tissues. This implies that these constituents break up, yielding their nitrogen in some lower form of combination which is usually carried off leaving the fat in the tissue. In accordance with this we find that, where general and extensive fatty degeneration occurs, there is simultaneously an excess of urea or other extractives in the urine. The splitting up of the albuminous constituents of cells implies a most serious alteration in their chemical constitution. In all such cases, therefore, it is to be inferred that the vitality of the cells is greatly reduced, and in some cases the condition approaches to, or is associated with, necrosis.

That fat may be formed from carbo-hydrates is shown by the fact that bees produce wax when fed on honey alone, this being a solution of sugar (Gundlach). The formation of fat from nitrogenous substances is proved by various facts. Thus the tissues of the body, including the nitrogenous constituents, are sometimes changed after death into **Adipocere**, a peculiar waxy substance, composed of fatty acids combined with ammonia and lime instead of with glycerine, and therefore more strictly a soap than a fat. This substance is occasionally found in graves, and it has been produced by leaving the dead body in running water for a time. Again, it has been shown that, in lactating animals fed with animal food carefully deprived of fat, the milk is even more abundant and rich in fat than in animals fed on diet containing much fat. Again, fresh milk becomes richer in fat and poorer in caseine (which is nitrogenous) during the first day after its withdrawal from the mammæ (Hoppe-Seyler).

The most conclusive proof that albuminous tissues yield fat is afforded by the effects of poisoning by phosphorus. When a dog has been deprived of food till all its spare fat has been exhausted and the nitrogen in the urine has reached a constant minimum of 8 grammes in the twenty-four hours, the administration of small doses of phosphorus causes a marked increase of the nitrogen, which may reach nearly 24 grammes. This is coincident with a very large increase of fat in the tissues of many internal organs.

The causes of fatty degeneration may be divided into those which, depending on some morbid condition of the blood, act on many organs, and those which have simply a local influence. We may therefore speak of a general and local fatty degeneration.

General fatty degeneration is produced by certain poisons, pre-eminently by phosphorus, but also by arsenic, antimony, iodoform, chloroform, and others. It occurs also in some general diseases in which the blood is greatly altered, in acute yellow atrophy of the liver, in some fevers, in pernicious anæmia, and in some other forms of anæmia. It has been produced artificially by confining animals in an over-heated space for thirty-six hours (Cohnheim). In these cases the altered blood has acted on the cells of the tissues and caused them to alter their chemical constitution. The change occurs mostly in the parenchyma of organs, as in the hepatic cells (Fig. 214), the renal epithelium, and striated muscular tissue, especially that of the heart, but it is also seen in some cases in other structures, such as the intima of arteries.

Local fatty degeneration is frequently the result of deprivation of blood, as where an artery is occluded. In the brain, occlusion of arteries is followed by softening of the cerebral tissue—a species of necrosis—but this is associated with the appearance of cells filled with finely-divided fat (the so-called compound granular corpuscles of Gluge). It is true that the fat here may be partly derived from the myeline of the nerve-fibres, but these fat-filled cells are not confined to the white substance, which alone contains myeline. They are present also in the grey substance where there is no myeline, and fat is also visible in the walls of the blood-vessels (as in Fig. 215). Inflammation is a frequent cause of local fatty degeneration, especially in certain parenchymatous organs, where the cloudy swelling often goes on to fatty degeneration (see Fig. 213). In quickly growing tumours, and even in slowly

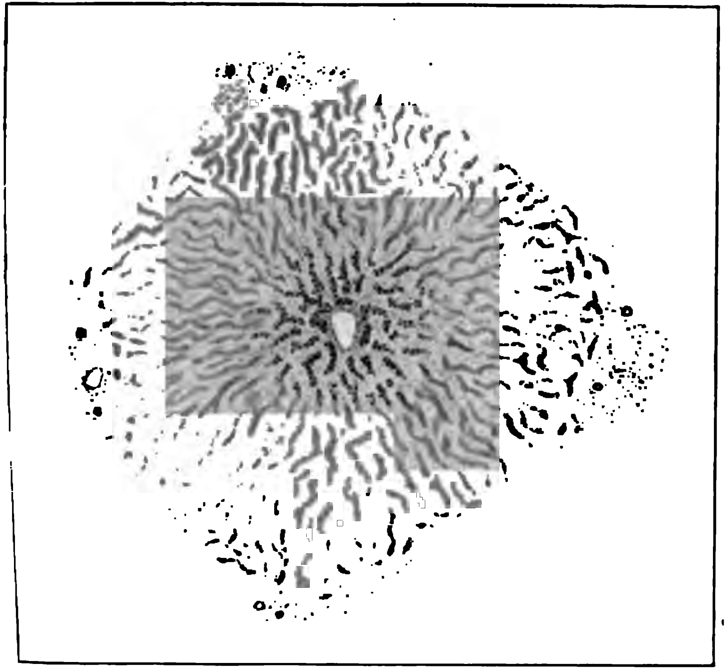


Fig. 214. Fatty degeneration of liver. Osmic acid. The fat granules are present in the central part of the lobule. × 50.

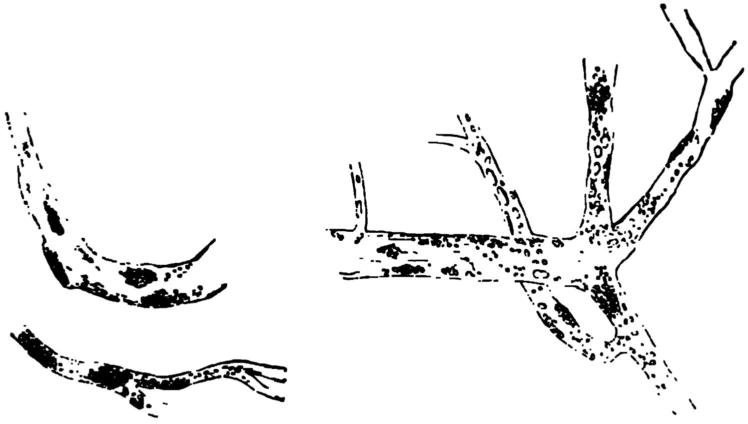


Fig. 215.—Fatty degeneration in the cerebral vessels in softening of the brain. (Paget.)

advancing cancers, the cells frequently undergo fatty degeneration. Lastly, nerve-fibres which have been divided show not only atrophy, but also fatty degeneration.

Some authors have endeavoured to account for fatty degeneration on the supposition that it is due to a deficiency of oxygen. It is said that in general fatty degeneration the blood is deficient in oxygen, and in the local form the tissues are deprived of oxygen. In the former case, however, there is usually an obvious alteration of the blood apart from simple anæmia, while in many local fatty degenerations there is no deprivation of oxygen, as in inflammations, in tumours, and after section of nerves.

Characters of the lesion.—The degeneration occurs mainly in the cells of the tissues. The fat, arising as it does by the chemical decomposition of the protoplasm of the cell, appears in the form of fine drops or granules, which are strongly refracting (see Figs. 215, 216, 217). These granules are separated from each other by the remains of the cell contents and are therefore isolated. It may happen in this way that, as in Fig. 216, a fatty degeneration occurring in a structure may render its constituent cells unusually distinct, their form being brought prominently out by the fat in them. As time goes on, the fat granules increase till the whole cell is filled with fine refracting oil drops, which remain isolated (see Fig. 217), each being surrounded by an albuminous envelope. The process is, in fact, very much like that which occurs in the cells of the mammary gland during the secretion of milk, the colostrum cells, which are often described as compound granular corpuscles, being like the fully degenerated cells.

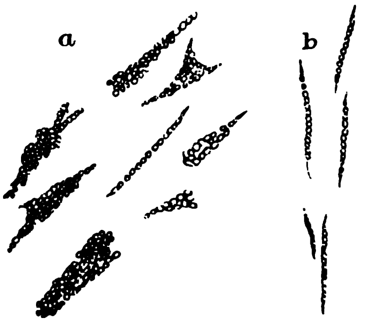


Fig. 216.—Fatty degeneration in an atheromatous aorta. The shapes of the cells brought out by the fat; *a*, from internal coat; *b*, muscle cells from middle coat. × 350.

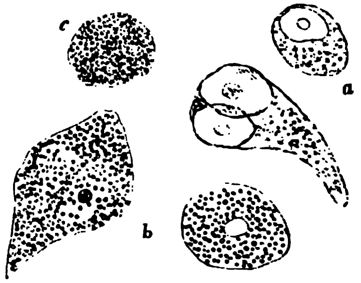


Fig. 217.—Fatty degeneration of cells in a cancer of the mamma; *a*, slightly affected; *b*, more so; *c*, completely fatty—the compound granular corpuscle. × 350.

When finely-divided fat suspended in a fluid is present in the living tissues, it is very readily absorbed. We know how readily the emulsified fat in the alimentary canal is taken up by the epithelium, and passed on into the lacteals. When milk is injected into the abdominal cavity of a living animal, or even laid on the surface of the diaphragm after death, it very quickly passes into the lymphatics. In the case of fatty degeneration of cells, if fluid be present, the cells disintegrate, an emulsion is formed, and absorption occurs just as in the case of milk.

But sometimes the fatty degeneration occurs in connection with structures not adapted to absorption, as in hydrocele, where the tendency is rather to transudation, or as in certain ovarian tumours. In that case, the fat undergoes further changes, resulting usually in the production of crystals of **cholestearine** (Fig. 218) or **margarine.**

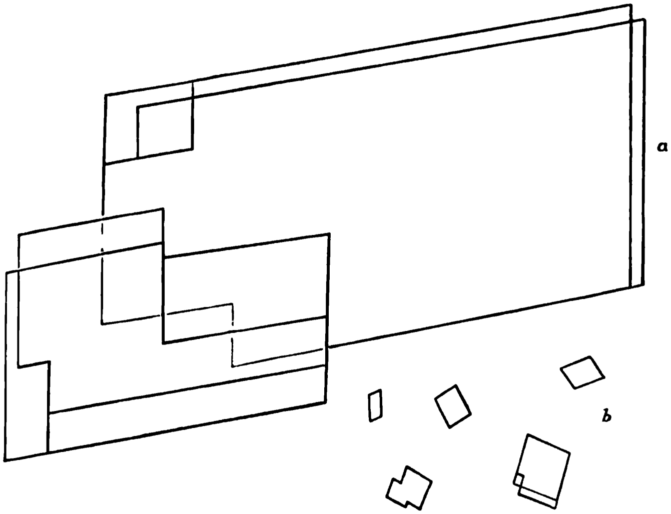


Fig. 218.—Crystals of cholestearine; *a*, large ones from an old hydrocele; *b*, from stagnant bile in gall bladder. × 350.

Cholestearine, which is an alcohol, occurs as a normal constituent of the central nervous tissue and of bile, in which latter it is dissolved. Its crystals are rhombic tables whose angles measure 79° 30′ and 100° 70′. On adding strong sulphuric acid carefully to a crystal of cholestearine, the crystal appears to melt from the edge inwards, and take on a fatty appearance, and by and by it gathers into a brown drop. On adding iodine and sulphuric acid to a crystal, there is at first a beautiful display of colours. **Margarine** occurs in the form of radiating needles such as one frequently sees inside the fat cells in adipose tissue.

Local fatty degeneration is not infrequently followed by **Calcareous infiltration,** where, from deficiency of fluid or otherwise, the fat is not absorbed.

We have already seen that in **Caseation** fatty degeneration is associated with necrosis.

V.—FATTY INFILTRATION.

By this term is meant the infiltration of free fat into the tissues. This condition is only in a restricted sense pathological, especially when it is general. It is necessary to distinguish fatty infiltration of the liver from other forms.

1. **Fatty infiltration in connective tissue.**—Adipose tissue is a form of connective tissue, and is, to a considerable extent, interchangeable with loose connective tissue. Adipose tissue is formed by the infiltration of fat into connective tissue cells, where it is laid down in store, and this store fat may at different times be variously abundant.

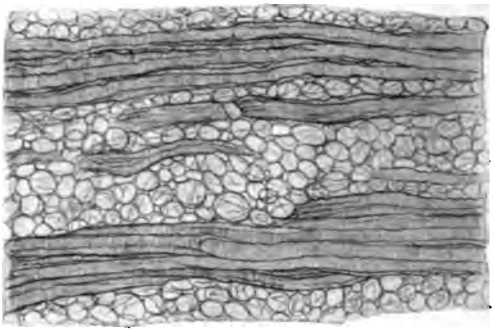


Fig. 219. Fatty infiltration of muscle. Pseudo-hypertrophic paralysis. The muscular fibres are narrowed and adipose tissue appears between them.

In **Obesity** an excess of fat is present in the body, and the fat is laid down in store chiefly in the subcutaneous connective tissue and the omentum, but also in other situations where loose connective tissue is present.

Around or in disused or atrophied organs it is common to find a fatty infiltration. A most typical example of this is afforded by **muscles** which have become fixed at their ends by the stiffening of joints. The muscle can no longer produce any movement, and its fibres gradually atrophy as we have already seen. At the same time, in the connective tissue around the muscle and in that which supports it, there is a great infiltration of fat, so that adipose tissue appears between and around the fibres. Then, again, in pseudo-hypertrophic paralysis—a disease chiefly of children—there is a similar process. The muscular tissue atrophies, but there is at the same time an excessive transformation of the connective tissue into adipose tissue, so that the wasting of the muscle is more than counterbalanced by the excess of adipose tissue, and there is thus a pseudo-hypertrophy (see Fig. 219).

A similar fatty infiltration occurs in **the heart** (Fig. 220), and may seriously incommode it in its action (see further on).

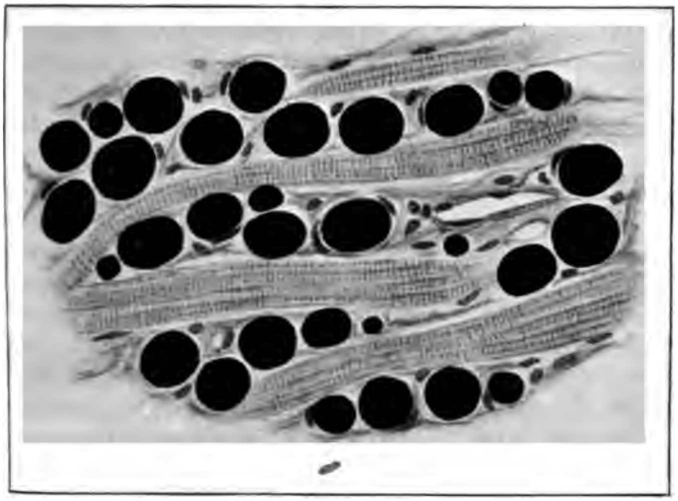


Fig. 220.—Fatty infiltration of heart muscle. Osmic acid. × 200.

Fat is often deposited in excessive quantity **around diseased and useless glands,** such as the kidney, pancreas, etc. In the contracted kidney of chronic nephritis there is often an excess of fat at the hilus, which may make the kidney appear much less reduced in bulk than it really is. In hydronephrosis there is often an enormous increase of the fat which normally surrounds the kidney.

2. **Fatty infiltration of the liver.**—Fat is often found in large quantities in the liver in cases where, in the subcutaneous tissue or elsewhere, there is an actual deficiency. The fat in the liver is in the peripheral parts of the lobules, and from this it is to be inferred that it has been brought by the portal blood, and that it is a store fat (see Fig. 221). This fatty infiltration occurs most frequently in phthisis pulmonalis.

Its accumulation in diseases such as phthisis may, in part, be accounted for by supposing that the fat which is normally used for the formation of the fatty acids and the cholestearine of the bile is not so used, and is therefore stored in the hepatic cells. It is known that the secretion of bile is greatly diminished in such cases, and that the bile is watery. In that case the fatty infiltration here would, like that in muscle, be due to diminished activity of the organ. Another view, and one having some appearance of probability, is based on the theory that one of the functions of the liver is to prepare fat for oxidation. Naumann (Reichert and D Bois Reymond's *Archiv*, 1871, p. 41) has shown that the liver fat is much mor oxidizable than ordinary fat, and that in the vertebrata the size of the liver is i inverse proportion to the activity of tl respiration, being largest in fishes ar smallest in birds. It is therefore suggest that in phthisis and cachectic diseases tl liver may produce an excess of easi oxidizable fat and store it up ready f use. Hence, perhaps, the utility of liv oils in cases of phthisis.

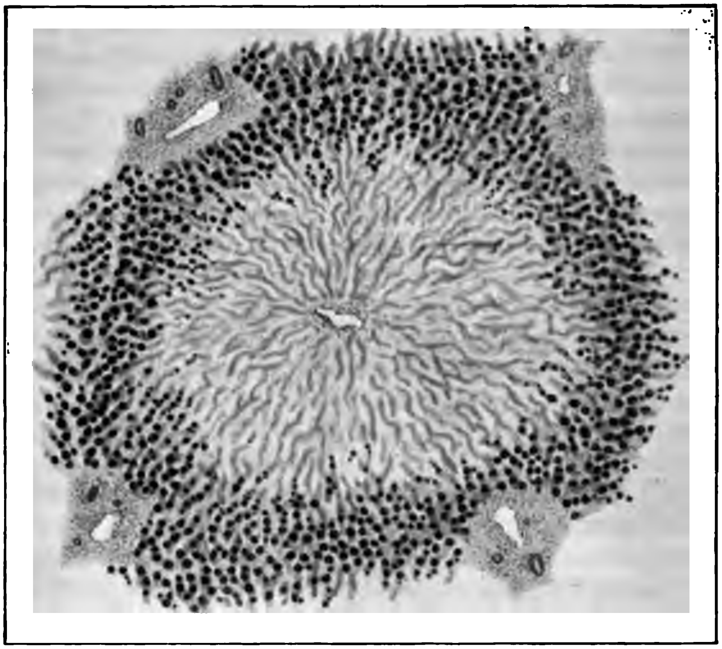


Fig. 221.—Fatty infiltration of liver. Osmic acid. The granules are limited to the peripheral parts of the lobules. × 50.

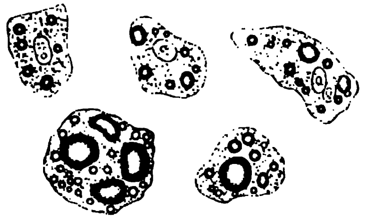


Fig. 222.—Fatty infiltration of the liver as seen in the fresh state. Isolated hepatic cells with drops of fat of various sizes. × 350.

We have seen that in fatt degeneration the fat appears in tl form of fine granules or drops, and that as these increase they remai isolated. In fatty infiltration there are, of course, first fine fat drop but as more fat is added the drops grow in size. In the case of tl conversion of connective tissue into adipose tissue, there is a single f drop in each cell, as in Fig. 220. In the case of fatty liver the fat drops are of various sizes (see Fig. 222), but, as a rule, much larger than in fatty degeneration. The size is by no means an absolute criterion, but it is an important practical indication. It is only in the liver that there can be much difficulty in distinguishing between fatty degeneration and fatty infiltration, and here the fact that in the latter the fat is deposited at first in the cells at the peripheral parts of the lobules, and continues more abundant there, is sufficiently distinctive. There is one exception to this in the case of the fatty liver of alcoholism. Here a fatty infiltration occurs which is diffused throughout the lobules.

VI.—PATHOLOGICAL PIGMENTATION.

The pathological variations in colour in the tissues come under a considerable number of different categories.

The endeavour has been frequently made to refer all pigments found in the body to the blood-pigment, but this relation has been definitely disproved for some (as in the case of pigments introduced from without), and rendered doubtful in others. The normal pigments in the body, those of the blood-corpuscles, of the skin, eyeball, etc., arise in cells and are formed by the cells elaborating them from the nutrient material afforded them. It is an assumption to suppose that the pigment of the skin is derived from the blood-pigment and not elaborated by the cells.

1. **Alterations of physiological pigmentation.**—The pigment of the skin varies much in different persons within physiological limits. There is an absence of pigment from congenital defect (*albinism*), and a congenital excess (*negrism*). The pigment also varies in the same person at different times; it is often increased by exposure to the sun, by pregnancy (*chloasma*), etc. A peculiar form of pigmentation is that in **Addison's disease**, in which certain parts of the skin assume a bronze colour. The excess of pigment here is not only in the rete Malpighii but in the papillæ of the cutis and around the veins. This disease is associated with tuberculosis of the suprarenal capsules, but the connection of the local disease with the pigmentation of the skin is not very clear.

2. **Pigmentation by hæmoglobin and its derivatives.**—The pigment of the red corpuscles of the blood, the **hæmoglobin**, is an unstable substance, and readily passes into other forms. Hæmoglobin contains iron, but the latter is in the so-called "masked" condition, *i.e.* it is so intimately combined that it does not give the usual reactions of iron, such as that with ferrocyanide of potassium and hydrochloric acid. These can only be obtained when the iron is in the "ion" form, as it is in solutions of inorganic salts. In certain pathological conditions this seems to occur, but the steps of the process are not well under-

stood. When a solution of hæmoglobin is heated to boiling it breaks up into albumen and **hæmatin.** The latter by further decomposition, as by treatment with strong sulphuric acid, yields iron in an inorganic form and an iron-free substance—**hæmatoporphyrin**—which is isomeric with bilirubin. Something like this seems to occur in blood clots. From blood extravasations, Virchow obtained a crystalline colouring matter which he termed **hæmatoidin**—now regarded as bilirubin; and later, Neumann described a substance—**hæmosiderin**—as the colouring matter of old clots and thrombi, which he affirmed gave the ordinary reactions for iron. It is difficult to reconcile this statement o Neumann with our present views of chemical reactions, and in al probability hæmosiderin is not a pure compound. As Kunkel ha previously attributed this reaction to the presence of ferric hydrate it may be that hæmosiderin is a mixture of this substance an hæmatoidin, *i.e.* bilirubin. The term, however, will be retained fo convenience. **Hæmin,** which is procurable artificially from blood (se Fig. 223), is the hydrochloride of anhydrous hæmatin. It is o importance from a toxicological point of view.

In **hæmorrhages** the tissues around usually become stained, an the pigmentation, with various alterations, may remain for year There are two different ways in which the pigmentation may occu In the first case the hæmoglobin is dissolved out of the red corpuscle and the coloured solution stains the tissues around. The dissolve pigment may be transformed into what Neumann called hæmosideri the ferrocyanide test giving a general blue staining. The pigment i then liable to be collected in cells, where it may assume a granular form or as hæmatoidin it may occur either as granules or crystals.

The other mode of pigmentation in hæmorrhage is that the re corpuscles are taken up by amœboid cells and their pigment undergoe transformation inside the cells. The effused blood acting as an irrita induces inflammation around, and the usual amœboid cells, acting a phagocytes, take up the red corpuscles. (See Fig. 224.) Many o these cells pass off by the lymphatics, but some may remain pe manently in the part. The red corpuscles inside the cells shrink, an their pigment goes through the transformation into hæmosiderin an hæmatoidin.

In some **chronic inflammations** there is a pigmentation whic presumably arises in a similar way to that described above, th hæmorrhage being by diapedesis. This pigmentation is met wit chiefly in the skin and the intestine. There is a similar pigmentatio in **passive hyperæmia,** due to hæmorrhage by diapedesis. This is see in the lungs, where we have the condition of brown induration, and i the liver where passive hyperæmia is usually associated with pigmentation of the hepatic cells.

Post-mortem pigmentation of the tissues should be carefully distinguished. After death dissolution of red corpuscles occurs as a result of putrefactive changes, and the pigment set free stains the tissues, more particularly the walls of the heart and vessels, but, by degrees, other structures also.

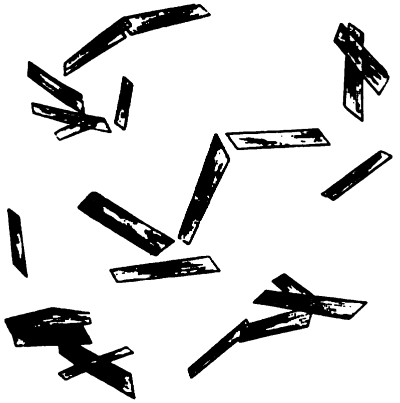


Fig. 223.—Crystals of hæmin prepared artificially by adding glacial acetic acid to a drop of blood, heating and evaporating to dryness. × 350.

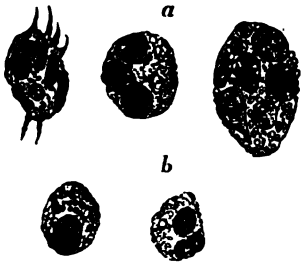


Fig. 224.—Cells containing blood-corpuscles from the neighbourhood of a hæmorrhage; *a*, with fresh corpuscles; *b*, with dark granules from disintegration of red corpuscles.

Melanæmia, as we have seen (page 232), is a name given to cases in which free pigment is present in the blood. It is the result of the destruction of the red corpuscles by the parasites of malarial fevers. The pigment is in the form of granules and flakes, and being deposited in certain organs leads to a coloration of them.

We frequently meet post-mortem with a black pigmentation, more particularly in the mucous membrane of the intestine, but also in other of the organs in the abdomen. This is partly a post-mortem appearance, but it owes its occurrence to conditions which have existed during life. The name **Pseudo-melanosis** has been applied to it. Its existence implies the presence of hæmosiderin, and the black colour is due to the action of sulphuretted hydrogen evolved by the putrid decomposition, on the iron of the hæmosiderin.

3. **Icterus or Jaundice** is a condition in which the blood contains a yellow pigment which stains the tissues of the body generally. The pigment is usually that of bile, namely, bilirubin. This substance is elaborated by the hepatic cells and secreted as a constituent of the bile. When the exit of the bile is hindered by obstruction of the ducts the pigment is re-absorbed and passes into the blood. Icterus which is thus due to the bile pigment is called **Hepatogenous**, that is, derived from the liver.

We have already seen that hæmatoidin is of similar constitution to bilirubin, and we may presumably have icterus from the formation of this pigment in the blood by destruction of the red corpuscles independently of the bile. This form of icterus is called **Hæmatogenous.** The exact domain of this form is not determined. The icterus of some acute diseases such as pyæmia and typhus fever i hæmatogenous. More doubtful is the **Icterus neonatorum.** Thi form of jaundice occurs in a large number of new-born children, an is usually regarded as due to a destruction of red corpuscles, occurring in consequence of the changes in the circulation at birth.

It is asserted by Birch-Hirschfeld that this icterus is hepatogenous. He say that the sudden change in the circulation at birth causes œdema of the interstitia connective tissue of the liver, and that this produces obstruction of the duct Cohnheim agrees with Birch-Hirschfeld that the icterus is probably hepatogenou but does not see sufficient evidence of œdema. He suggests that as there is a birth a sudden increase in the secretion of bile, the ducts may take some tim to accommodate themselves. Recklinghausen believes the icterus to be hæmatogenous on the apparently sufficient ground that the fæces are coloured wit bile, and that therefore the bile ducts are not obstructed.

A peculiar feature in icterus neonatorum is the occurrence of **Crystals** of hæmatoidin or bilirubin in the kidneys, and also in the tissues and blood. That i to say, the pigment not only stains the tissues, but is deposited in the crystallin form. It is probable, however, that this crystallization is a post-mortem phenomenon. Hæmatoidin crystals may be found even where there is not enough pigmen present to produce jaundice.

4. **Pigmentation in tumours.**—In certain sarcomas and cancers brown pigment is present in the cells of the tumours, giving to th tissue a brown or black colour. The pigment here has the chemica characters rather of melanin than of blood-pigments and is presumably elaborated by the cells. These tumours mostly take origin i structures where pigment cells normally exist, as in the choroid o the eye, the superficial layers of the cutis, the pia mater (Virchow and the conjunctiva of the eye, where it passes into the cornea Such tumours also originate in pigmented nævi, in the rete Malpighi and in the cornea (especially in horses). In some of these cases th melanin passes into the urine, where it may deeply colour th secretion (Tennent and Coats).

5. **Pigmentation from without.**—Pigmented substances introduce may lodge in the tissues and even permanently colour them. **Salt of silver,** when long administered, or when taken in excess in on dose, may cause a bluish staining of the skin—**Argyria.** Silver also deposited in the tissues of internal organs.

The **Dust of the air** which is inhaled, passes to some extent int the substance of the lungs, and gives a dark colour to them. (S under Lung Diseases.) Workers whose trades expose them to variously coloured dust, present similar pigmentations of the lungs. **Tattooing** is an operation by which granular pigments are introduced, and lodge in or under the skin and in the lymphatic glands.

6. **Pigmentary Atrophy.**—When coloured tissues atrophy there is usually a concentration of their pigment. Thus we have a brown atrophy of muscle, especially of the heart, and a deepened coloration of the fat in emaciated persons and in old age.

Literature.—Virchow, Virch. Archiv, vols. i., ii., iv., vi., Geschwülste, vol. ii.; Addison, Dis. of suprarenal capsules, 1855; Langhans, Virch. Arch., vol. xlix.; Neumann, Virch. Arch., vol. cxi., 1888; Dürck, *ibid.*, vol. cxxx., 1892; Rindfleisch, Path. Histology; Kehrer, Stud. üb. Ikterus neonatorum; Birch-Hirschfeld, Virch. Arch., vol. lxxxvii.; Cohnheim, Allg. Path., vol. ii., p. 75; Recklinghausen, Allg. Path., p. 437; Gussenbauer, Virch. Arch., vol. lxiii.; Kunkel, Virch. Arch., vol. lxxxi.; Rindfleisch and Harris, Virch. Arch., vol. ciii.; Tennent and Coats, Glasgow, Med. Jour., xxiv., 1885; Neumann (Pseudomelanosis), Virch. Arch. cxi.; Garrod (literature) in Encyclop. medica., ix., 1901, gives a short resumé of our knowledge of the pigments of the body and excreta.

VII.—AMYLOID DEGENERATION.

This name is applied to a condition in which the constituents of the tissues are converted into a substance the chemical characters of which are different from those of any normal principle in the body. The degeneration is also called **waxy** and **lardaceous** from the physical characters of the substance produced. This may be called for convenience **amyloid substance**, and, as the name suggests, was originally supposed to be allied to starch. It has really no chemical relation to starch, being a nitrogenous substance and a modified serum-albumin. It resembles starch, however, in respect that it gives a colour reaction with iodine.

The presence of amyloid substance is determined by its physical characters and by certain colour tests. The earliest known of these latter is the reaction with iodine. The iodine reaction is useful for roughly testing macroscopically at the time of the post-mortem. For this purpose a watery solution consisting of iodine 10 grains, iodide of potassium 20 grains, and water 4 ounces, is poured on the surface of the structure to be tested. A mahogany red colour indicates the presence of amyloid matter. The further addition of dilute sulphuric acid sometimes produces a deeper red or a bluish or greenish colour.

For microscopic purposes watery solutions of methylviolet or gentianviolet as introduced by Cornil are most suitable. These dyes produce a rose-pink colour with the amyloid substance, while normal tissues are stained blue. In testing by iodine microscopically a solution half the strength of that mentioned above should be used.

The substance itself has a peculiar bright translucent glancing appearance (see Fig 225), and, as the structures in which it occurs are enlarged, they are often remarkably prominent under the microscope. It is a very dense heavy material, and, after death, at least, is somewhat brittle, but the usual absence of hæmorrhage in amyloid organs would seem to indicate that it is not so during life.

Causation.—Looking to the history of the cases in which amyloid degeneration occurs it is clear that it is to be referred primarily to an alteration in the blood. The disease is not an independent one, but comes on in certain cachectic states due to chronic tuberculosis, syphilis, diseases of bone involving prolonged suppuration, chronic dysentery, etc.

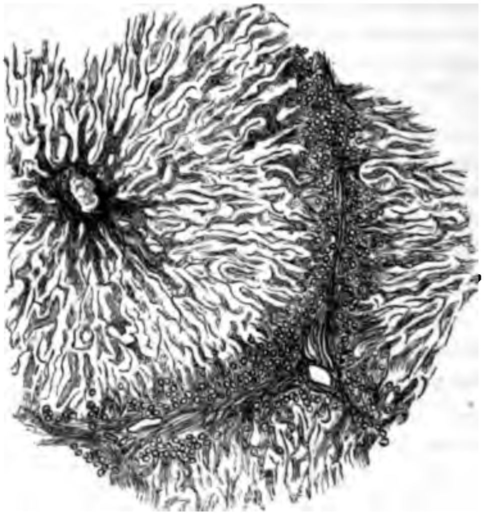


Fig. 225.—Advanced amyloid disease of the liver. The arrangement of the transparent amyloid material suggests its formation in the capillaries. The round bodies at the peripheral parts of lobules are fat drops, there being slight fatty infiltration. × 70. (THIERFELDER.)

As more unusual causes of amyloid degeneration, may be mentioned leukæmia, Hodgkin's disease (malignant lymphoma), very rarely cancer or sarcoma. It is frequently associated in the kidney with chronic inflammation of that organ, but it is doubtful whether the latter is to be regarded as its cause, for, on the one hand, amyloid disease may lead to nephritis, and, on the other, both conditions may be the result of syphilis.

It will be seen that in the forms of disease mentioned as leading to amyloid degeneration there are, for the most part, morbid poisons in the blood. It is probable that the action of these agents is the direct cause of the condition rather than any drain on the system such as has been generally asserted as the cause. Whilst in tuberculosis there is usually a prolonged discharge, yet in syphilis amyloid degeneration is common without any such condition.

It is more difficult to determine the nature of the connection between the condition of the blood and the disease in the tissues. By some it is supposed that the amyloid substance arises in the blood by modification of the albumen and is then infiltrated into the structures. But this view cannot, for various reasons, be accepted. In the first place, the substance is eminently insoluble, and it is difficult to understand how it can be carried by the blood; besides this it does not displace the normal structures simply, but replaces them, these structures being converted into the amyloid substance. It is more consistent to suppose that the tissues are reduced in vitality by the altered condition of the blood, and that the albumen of the blood enters into combination with the protoplasm in such a way as to produce this peculiar substance. The process may perhaps be compared to the coagulation of the tissues, which, as we have seen, sometimes occurs when they undergo necrosis, the tissues entering apparently into a chemical union with the fibrinogen in the fluid exuded from the blood-vessels, so as to form fibrine or some substance allied to it. Amyloid matter has frequently been compared to fibrine, and Dickinson has suggested its affinity with de-alkalized fibrine. The existence of localized amyloid disease is strongly confirmatory of this view. In this condition abnormal structures enter into the peculiar chemical combination with the albumen of the blood, while normal structures do not. In this connection also, the fact that amyloid disease affects the connective structures of the body is not to be forgotten. It is as if the chemical basis of these structures had a special relation to the amyloid substance. Amyloid disease is therefore essentially a degeneration, although, in order to form amyloid substance, it is necessary to have, added to the tissue, material from without, and this adds greatly to the bulk and weight of the structures.

According to Wichmann the amyloid matter is always interstitial, that is to say, between the cells. He holds that it occurs when the cells, owing to anæmia, are no longer able to assimilate the normal albumen exuded from the blood. The albumen lying in the spaces of the tissues undergoes a chemical transformation into the amyloid substance. This suggestion does not seem a likely one.

Changes in the tissues.—Amyloid degeneration, being due to a condition of the blood, is nearly always present in a number of organs simultaneously, although its degree varies greatly in different organs. It is particularly frequent in the spleen, liver, kidneys, intestine, and lymphatic glands, but it may occur in almost every organ of the body.

In all these organs it begins in the **walls of the blood-vessels,** more especially the walls of the capillaries and smaller arteries, or in the **connective tissue.** In advanced cases the amyloid substance is in such quantity, and the proper tissue of the organs is in many cases so much atrophied, that it is often difficult to determine its precise seat. In early cases, however, it will be found that the arteries and capillaries are nearly always the primary seat. It is readily seen, in the liver for instance, that the capillaries are affected, the hepati cells undergoing atrophy. Even in advanced cases the arrangemen is often suggestive of radiating capillary tubes, as in Fig. 225. In the kidneys, again, it is always the vessels which are first affected although extension may occur to the basement membrane of th tubules. (See under Kidney.) In the spleen the arteries are mostly affected, and in addition to these either the walls of the sinuses in th pulp or the reticulum of the Malpighian bodies. (See under Spleen.)

The distribution of amyloid disease varies greatly in different cases, both i regard to the organs chiefly affected and the parts of the organs. Thus in phthisi pulmonalis it may be chiefly present in liver, spleen, or kidney, and it may b absent in one of these organs while present in the others. Of the two forms o amyloid disease of the spleen, one (the sago spleen) is characteristic of phthisi pulmonalis, while the other (the diffuse waxy spleen) is probably the form mos frequently met with in syphilis.

Considerable discussion has occurred as to the existence of amyloid disease i **epithelial structures.** It is now generally admitted that these are rarely if eve involved, and if they are it is in advanced cases. In the liver it is admitted tha the arteries and capillaries are chiefly affected, but Kyber and others have asserte that the hepatic cells are involved. The author has not been able to detect any amyloid change in the hepatic cells.

The amyloid substance is a very inert matter. It is insoluble in water and alcohol and even in gastric juice. During life it renders the structures involved passive, so that they are incapable of vital changes. This material is insoluble in the juices of the body, but consistently with its character as inert matter it gives ready passage to fluids, so that during life the prominent symptom of amyloid disease in the intestine is diarrhœa, and in the kidneys an excessive discharge of watery urine.

A frequent result of amyloid disease is diminution in the calibre of the blood-vessels, and this must lead to **anæmia** of the organs To this may be partly ascribed the **fatty degeneration and atrophy** which so frequently accompany the process, although these are also due to the pressure of the swollen structures.

Structures which have undergone amyloid degeneration are greatly increased in bulk and weight, and this tells on the organ as a whole. The liver, spleen, and kidneys are often greatly enlarged, and they present a peculiar dense translucent appearance, which has given rise to the names waxy and lardaceous disease, often applied to amyloid degeneration.

Localized amyloid disease.—This does not occur in tissues previously unaltered; there is always some preceding local lesion. It is met with chiefly in new-formed inflammatory tissue and cicatrices, especially when of syphilitic origin, and also in tumours. It has been seen in syphilitic cicatrices in the liver, tongue, and larynx, in degenerating cartilage, etc. In some cases the piece of amyloid tissue is of considerable size, and as it differs in its hard translucent character from the tissues around, it may itself look like a tumour.

Amyloid concretions. Corpora amylacea.—In old extravasations of blood in the lungs we sometimes meet with round or oval stratified bodies of small size (see Fig. 226 *b*), which somewhat resemble starch granules, and give with iodine the amyloid reaction. Sometimes they contain in their central parts a foreign body, such as a blood crystal. Again in the prostate gland (*a*) we meet with concretions of considerable size, it may be visible, as brown granules, to the naked eye, with some of the characters of stratified amyloid concretions. They are also met with in the tissues of the central nervous system (*c*); they are present in the normal brain, especially in the ependyma of the ventricles, but in cases of sclerosis they may be present in enormous numbers.

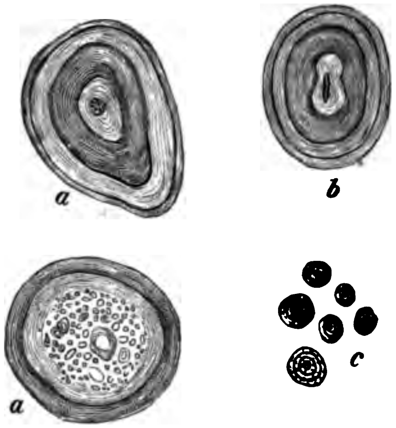


Fig. 226.—Corpora amylacea: *a*, from the prostate; *b*, from a haemorrhagic infarction of the lung; *c*, from the spinal cord. × 400. (ZIEGLER.)

The reaction of these bodies is not quite the same as that of ordinary amyloid matter. They give with iodine more of a blue tint, and that without adding sulphuric acid. They sometimes fail to give a red colour with methylviolet. Their significance is not usually very great from a practical point of view, but their presence under these various conditions seems to prove that various albuminous substances may undergo conversion into amyloid or some allied substance.

In the nervous system there are frequently developed artificially clear glancing bodies which somewhat resemble amyloid bodies. They occur as the result of the action of alcohol in hardening the tissue, and this agent should therefore, as a general rule, be avoided in preparing the brain and spinal cord for histological investigation. The bodies give with iodine a pale yellow, and with methylviolet a reddish colour. They are devoid of pathological significance, although some writers have referred to them as true morbid lesions. (See a review of the subject by Middleton, who regards them as formed by the action of alcohol on the myeline of the medullated nerve-fibres.)

Literature.—Virchow, Virch. Arch., vi.; Wilks, Guy's Hosp. Rep., 1856; Kekulé, Heidelberg Jahrb., 1858; Kühne und Rudneff, Virch. Arch., vol. xxxiii.; Cornil, Arch. d. Phys., 1875; Kyber, Virch. Arch., vol. lxxxi.; Budd, Lancet, 1880; Report on lardaceous disease, Path. Soc. trans., vol. xxii.; Fagge, Path. Soc. trans., vol. xxvii.; Dickinson, Discussion on lardaceous disease, Path. Soc. trans., vol. xxx.; see also Greenfield, Goodhart, and others in this discussion; Coats (Amyloid dis. in Phthisis), in Gairdner and Coats' Lect. to practitioners, 1888; Zahn (Local amyloid dis.), Virch. Arch., vols. lxxii. and lxxiii.; Middleton, Glas. Med. Jour., xxii., 1884; Wichmann (Bibliography), Ziegler's Beiträge, xiii., 1893; Krawkow, Centralb. f. Allgem. Pathol., vi., 1895, and Arch. f. exp. Path., xl., p. 195; Maximow (literature), Virch. Arch., cliii., 1898; Lubarsch (full literature), Lubarsch and Ostertag, Ergebnisse, i., 1895, and iv., 1899; Ophüls, Jour. of exp. med., v., 1900.

VIII.—MUCOUS, COLLOID, AND HYALINE DEGENERATIONS.

There are many pathological conditions in which translucent, glancing substances appear in the tissues, and it is frequently difficult or impossible to determine the chemical and other relations of these substances, which were all at one time called colloid substances. In regard to one of them, namely, amyloid substance, the reactions are so definite that it can readily be detected even in small quantities. It has, therefore, been separated from this group. Mucin is also a tolerably definite substance, whose reactions generally allow of its detection. But even in regard to it there are cases in which its presence is doubtful, and there remain many conditions in which the colloid or hyaline appearance is visible, but the nature of the change is obscure.

Most authors use the term colloid degeneration to cover the more indefinite forms, using a term which formerly had a wider significance. Recklinghausen has introduced the term **Hyalin** to indicate a substance having a clear translucent appearance. This author includes under this name both solid and semi-fluid substances having the optical characters mentioned. As the term means glassy, it seems hardly consistent to call by this name tenacious fluids, such as that found in the thyroid gland in some cases of goitre. Perhaps it may be convenient to retain the term colloid for the semi-fluid matters, and hyaline for the more solid.

1. **Mucous degeneration.**—This is characterized by the presence in the tissues of **Mucin.** This is a normal secretion of certain glands and is a body with definite chemical reactions. It is closely allied

to albumen, but it is precipitated by dilute mineral acids, and by organic acids (acetic acid), and is not re-dissolved by excess of acid. With alcohol it gives a membraneous and fibrous coagulum, which is partly re-dissolved in excess of water. Albumen, on the contrary, is not precipitated by organic acids, and its precipitate with alcohol is flocculent, and not re-dissolved by water. Mucin is detectable by a colour test, the dye used being toluidin-blue or thionin. These substances, which are nearly allied to methyl-blue, produce a blue nuclear staining, but give a red colour with mucin. The physical characters of mucin are notable in that, even in small amounts, it gives fluids a sticky, tenacious character. Thus a fluid containing 5 per cent. of mucin is tenacious, while the blood serum which contains 9 per cent. of albumen is quite liquid. **Paralbumin** is closely allied to mucin, if not the same substance.

Mucin is present pathologically either in cells or in the intercellular substance. **In cells** it has its physiological type in the secretion of mucus. This takes place by a transformation of epithelial cells, which may be either in proper mucous glands or else on the surface of mucous membranes. The cells show in their protoplasm a clear substance which gradually distends them, and they become goblet cells. The mucin is discharged, the cell being either destroyed or returning to the normal condition. An exaggeration of this process occurs in catarrhs of mucous membranes, but this can scarcely be called mucous degeneration. There may also be an accumulation of mucus in a cavity or cyst, but this also is to be distinguished from degeneration.

A definite mucous degeneration occurs in tumours, notably in ovarian tumours and in certain cancers. In the colloid ovarian cystoma, the mucous (or colloid) matter is produced by a process of secretion in glandular structures, goblet cells being characteristically present. (See Fig. 227.) In colloid or mucous cancers the epithelial cells of the tumours undergo a mucous transformation. The tumours which present this change have mostly their seat where cylindrical epithelium is a normal constituent.

Mucin differs from albumen in respect that it has no tendency to become absorbed, so that a cavity containing a mucous fluid is not likely to have its contents reduced by absorption.

Mucin is present in the **intercellular substance** in the tissue of the umbilical cord, which may be taken as the type of **Mucous tissue.** In this tissue the intercellular substance is composed of a soft jelly. Tumours occur which are composed of a similar tissue. (See Myxoma.) A true mucous degeneration occurs when the dense matrix of cartilage or bone becomes transformed into a jelly containing mucin (see Fig. 122, p. 295), or when the adipose tissue becomes like mucous tissue.

Myxœdema is a condition in which mucin is present in the skin, subcutaneous tissue, etc. It is associated with changes in the thyroid gland. (See p. 233.)

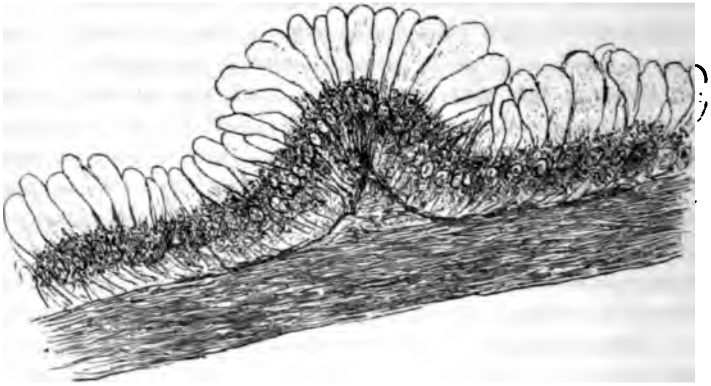


Fig. 227.—From the internal surface of a colloid ovarian cyst. The lining epithelium is mostly in the form of goblet cells, the superficial parts having clear transparent contents. × 350.

2. **Colloid degeneration.**—Under this name are included conditions in which the cells of structures secrete or become converted into a clear homogeneous substance, this transformation implying the destruction of the cells. It occurs almost as a physiological process in the **Thyroid gland**, as colloid matter is always present in later life in that gland. It forms an important element in the commonest form of **Goitre**, in which there is an enlargement of the gland. The thyroid gland consists of saccules lined with epithelium. The epithelial cells become colloid and the saccule comes to be occupied by a translucent clump of colloid matter, which by swelling up causes enlargement of the saccule. In the **Kidneys** we frequently find cysts occupied by colloid matter, which has arisen by transformation of the epithelium of the tubules or Malpighian bodies.

3. **Hyaline degeneration.**—Recklinghausen has introduced this term to designate conditions in which a clear homogeneous substance of a vitreous appearance is present, which does not yield the reactions of amyloid substance or mucin. This **Hyalin** has special reactions to some staining agents, being deeply coloured by most of the acid dyes. Thus carmine, picro-carmine, and to a less extent, hæmatoxyline, eosine, and acid fuchsine stain it deeply. It is an inert substance and its presence implies that the structures involved are obsolete if not dead. The substance is insoluble in water and alcohol, and is unaffected by acids and alkalies. It is insoluble in the juices of the tissues; at most it swells up when acted on by

them and remains as an inert substance. Like amyloid matter and mucin, it arises chiefly by transformation of cells, but there are some conditions included by Recklinghausen, in which this can hardly be said to be the case.

It is not asserted by Recklinghausen that hyalin has a determinate chemical constitution, and there are probably many different conditions included in the name. The following is a list of these:—(1) Colloid degeneration; (2) Some instances of coagulation-necrosis, and more particularly the waxy degeneration of muscle; (3) Tube casts in the kidneys (hyaline cylinders) and similar structures met with in inflammations of the ducts of the sweat glands, and in the ovarian follicles; (4) Hyaline matters in many tumours, as in lymphomas, sarcomas, and cancers, as well as in tubercles; (5) On mucous membranes, forming the main constituent of diphtheritic membranes; (6) In thrombi and fibrinous exudations, where the fibrine, at first forming a net-work, becomes converted into a hyaline homogeneous material; the thrombi in aneurysms often assume this character; (7) In the eye as prominences in the hyaloid membrane.

Literature.—Recklinghausen, Allg. Path., p. 404; Ernst, Virchow's Archiv, cxxx., 1892; Marchand, Eulenburg's Realencyklop., 1895; Lubarsch, Lubarsch and Ostertag, Ergebnisse, i., 1895, and iv., 1899.

IX.—GLYCOGENIC INFILTRATION.

This is the term usually employed to designate the occurrence of glycogen in situations where it is not normally present, or its presence in excess in structures in which it normally exists. The possibility of the existence of a glycogenic degeneration, as distinct from an infiltration, has been asserted, but without demonstrable proof.

Glycogen occurs in the tissues either in solution or in the form of hyaline granules or droplets. These are found mostly within the cells, but also at times in the intercellular substance.

This carbohydrate is soluble in water and gives with iodine a brownish-red coloration; in these two respects differing from amyloid material. Further, glycogen does not give the bluish-green iodine reaction on subsequent addition of sulphuric acid. In all investigations fresh tissues should be employed, as the conversion of glycogen into sugar takes place soon after death. The tissues may be examined fresh or after hardening in absolute alcohol. In applying the iodine test, alcoholic solutions or solutions of iodine in gum or glycerin are used. Gentianviolet and carmine also in special combinations give excellent results.

Glycogen occurs normally in the adult in the liver, in the muscles (including the heart), in the blood serum, in the leucocytes, in cartilage, in the epithelium of the body of the uterus, and probably in many other situations. It has been found in almost every organ in the embryo.

Its presence has been detected in many pathological conditions. Thus in diabetes it is present in the blood, in the liver, and in a marked degree in the renal epithelium, especially in the loops of Henle. In acute suppurative inflammations the leucocytes in the exudation have been shown to be the seat of glycogenic infiltration, and in the blood of leukæmia and cachectic diseases generally glycogen may be demonstrated in the leucocytes. Further, glycogen has been met with in a large number of different tumours, arising in various organs and tissues, *e.g.* in cancers of the testes, in some forms of renal tumour, in sarcomas of bones, in enchondromas, endotheliomas, etc. In certain other tumours glycogen is absent. According to Langhans it is rarely, if ever, seen in cancers of the mamma.

Literature.—Barfurth, Arch. f. mikr. Anat., 25, 1885; Ehrlich, Zeitschr. f. klin Med., 6, 1883; Langhans, Virch. Arch., 120, 1890; Czerny, Arch. f. exper. Path., 33, 1893; Trambusti, Centralb. f. allgem. Path., iii., 1892; Lubarsch, in Lubarsch and Ostertag, Ergebnisse, i., 1895, and iv., 1899. Directions for staining glycogen will be found in the Encykl. d. Mikroskop. Technik, 1903.

X.—CALCAREOUS INFILTRATION AND CONCRETIONS.

By these terms is meant the pathological deposition of lime-salts. In **Ossification** we have the salts of lime united with an organic matrix, and the tissue has a definite structure in which living, active cells are present. In **Calcareous infiltration** the same salts, chiefly the carbonate and phosphate of lime, are deposited in tissues without entering into any proper union with them, and, in fact, the deposition of the lime is in itself evidence that the tissue has virtually lost its vitality. A **Concretion** is a solid body, formed generally by deposition from a fluid. Such solid bodies consist in many cases of lime-salts.

Causation.—Lime-salts or other soluble matters may be deposited because they are present in excess. In cases of rapid destruction of bone, as by an advancing cancer, the absorbed lime-salts are present in the blood in excess, and we may have a **metastatic calcification** of the lung or intestine. There may be thus an incrustation such as to make the tissue like pumice-stone. In some cases of this kind there has been a co-existent disease of the kidneys hindering the due excretion of the lime-salts.

In most instances, however, the presence of **dead or obsolete matter** or a foreign body is the chief determining cause of deposition. The blood and principal fluids contain lime-salts in solution, and, under certain circumstances, these are liable to precipitation.. In the living tissues there is a continual circulation of the fluids, and these latter do not linger long enough to undergo any serious chemical change.

In dead or obsolete structures, on the other hand, the juices will lie stagnant, and are liable to undergo chemical changes. Both in the case of concretions and infiltrations there is usually a foreign body or piece of dead matter as the centre of deposition. In addition, the circumstances are frequently such as to cause stagnation of the fluid.

Characters of the lesions.—The lime-salts are deposited in the first instance in the form of fine globular granules, either in the protoplasm of cells or in the intercellular substance. The structure is as if dusted with refracting granules, and the appearances in many respects resemble those of fatty degeneration. (Fig. 228 *a.*) As the salts accumulate, the appearance of granules is somewhat lost and a more continuous petrifaction results. (Fig. 228 *b.*) Sometimes the structures becomes in consequence homogeneous and somewhat translucent, as in Fig. 229. The addition of a dilute mineral acid causes the salts to dissolve, and, as carbonates are nearly always present, solution occurs with evolution of gas.

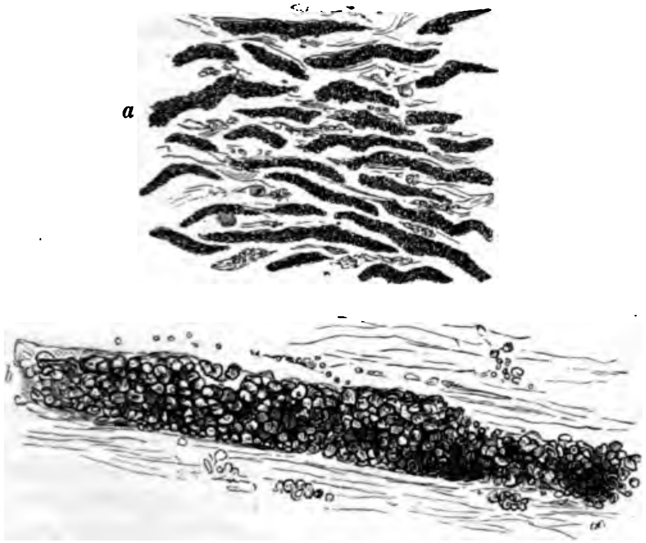


Fig. 228.—Calcareous infiltration in a tumour: *a*, cells of smooth muscle filled with lime granules; *b*, a blood-vessel converted into a solid rod. ×350.

Examples of this process are very numerous. A minute parasite, the trichina spiralis, occurs in the embryo form in the muscles of man and animals; it lies there quiescent, coiled up spirally and surrounded by a capsule. It is virtually a foreign body, and the capsule is by degrees impregnated with lime, assuming an opaque appearance at its poles

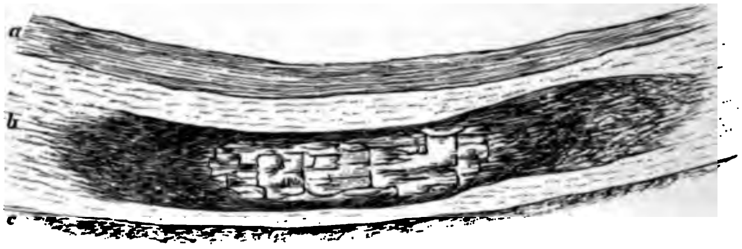


Fig. 229.—Calcareous infiltration of the middle coat in an artery. The lime salts have aggregated together so as to produce a crystalline appearance. × 22.

(Fig. 230). If the embryo itself dies, it also may become impregnated with lime (see Fig. 230, lower part). Sometimes an extra-uterine fœtus dies and remains inside the abdomen as a foreign body. It becomes surrounded by adhesions and partially encapsuled. The capsule and superficial parts of the fœtus become through time encrusted with lime, forming the so-called **Lithopædion**. Again, an inflammatory exudation in the pericardium may dry in and become impregnated with lime. In phthisis pulmonalis, if healing occurs, the contents of cavities and caseous matter may dry in and become surrounded by a capsule; impregnation with lime results, leading to a pultaceous or mortar-like material, which may ultimately condense into a stony mass. (See

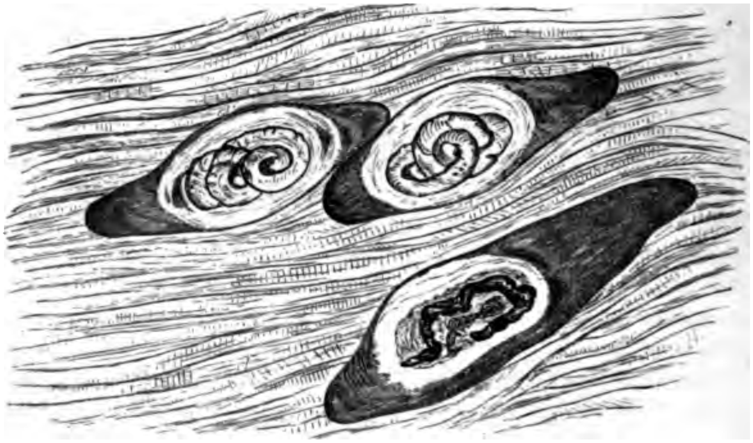


Fig. 230.—Trichina spiralis in muscle. The capsules infiltrated with lime, and in one case a dead worm shrivelled and impregnated with lime.

Tuberculosis.) Again, in valvular disease of the heart, due to chronic endocarditis, the new-formed connective tissue, by its contraction, becomes hard and dry and virtually obsolete, and deposition of lime-salts occurs.

These are examples of calcification of foreign bodies of pathological products, but we may have the process occurring in the ordinary tissues when they have become obsolete. In the middle coat of the arteries of old people, calcareous infiltration, beginning in the muscular fibre-cells, frequently leads to massive petrifaction of the arteries (see Fig. 229), so that they form rigid tubes. The cartilages of old people are also liable to impregnation with lime. The crystalline lens of the eye may be the seat of a similar deposition in certain forms of cataract.

In some cases the calcification is followed by a true ossification. Calcareous infiltration of the middle coat of arteries is not infrequently associated with ossification (Paul, Coats), and the calcification of the ribs of old people frequently passes into ossification. Again, the author found in an old hydatid cyst in the liver true bone associated with calcification. In these cases the rigid calcified structure probably acts as a foreign body, inducing the formation of granulation tissue around it. The granulation tissue may eat into the calcareous mass, and it looks as if the presence of lime-salts induced it to develop into bone rather than into ordinary connective tissue.

Literature.—WEBER, Virch. Arch., vol. vi.; VIRCHOW, ibid., vols. viii., xi., xx.; ZAHN, ibid., vol. lxii.; KYBER, ib., vol. lxxxi.; PAUL, Path. Soc. Trans., vol. xxxvii., p. 216; COATS, Glas. Med. Jour., vol. xxvii., 1887, p. 265; COHN, Virch. Arch., vol. cvi. ZIEGLER's Lehrb. d. allgem. Pathol., latest edition, contains numerous references.

SECTION XI.

ANIMAL PARASITES.

A. **Entozoa or Internal Parasites**, their general characters and effects. I. **Protozo** (1) Amœba. (2) Coccidia. (3) "Hæmatozoa" of malaria. II. **Trematoda** Flukes, chiefly Distoma hepaticum, sinense, and hæmatobium. III. **Cesto** or tape-worms. (1) Tænia solium, structure and development; Cysticerc cellulosæ, its scolex form. (2) Tænia mediocanellata. (3) Tænia echi coccus, forming hydatids; its cysts, brood-capsules, heads and laminat membrane. (4) Bothriocephalus latus. Other tape-worms. IV. **Nemato** or round-worms. (1) Trichina spiralis, its embryonic and adult form effects of migrations. (2) Ascaris lumbricoides. (3) Oxyuris vermicular (4) Trichocephalus dispar. (5) Ankylostomum duodenale. (6) Fila medinensis. (7) Filaria sanguinis, its periodicity in the blood; relati to chylous urine and lymph-scrotum.

B. **Epizoa or External Parasites**. (1) Arachnidæ, chiefly Acarus scabiei a Pentastomum denticulatum. (2) Insecta, chiefly Pediculi and Pul irritans. Larvæ of insects in wounds, skin, and bowels.

THE Animal Parasites represent a much wider extent of the ani kingdom than the vegetable parasites do of the vegetal kingdom. We have the lowliest forms of animal life, the protoz comparable with the bacteria in respect that they are unicellu organisms, and we have animals as highly organized as the Insec With this great variety in organization we have also great differen in seat, effects, and other characteristics.

The Animal Parasites live in or on the living tissues of the affect animal, which is called their host. They produce their effects, part by using up the nutritive material of the body, partly irritati and injuring the structures, and partly also, as is probable in so instances, by producing toxic agents. This last is, however, in t case of the animal parasites, a very infrequent effect as compar with that of the vegetable parasites.

I.—PROTOZOA.

The pathogenic unicellular organisms at the lowest position in t animal kingdom are by no means so well known as the correspondi vegetable organisms. Of late years much attention has been paid to them, and there are indications that there may be in their case a wide field of pathogenesis still to be discovered. The presence of protozoa in the blood in malaria suggests that in some of the specific fevers agents of this class may exist.

At the present stage of the inquiry modes of isolation and of cultivation are still to a large extent to be discovered. It is scarcely to be expected that the same media will be suitable for animal organisms as for vegetable. For a similar reason the morphology and classification of the group is also in an initial stage.

1. **Amœba.**—This, the lowest form of animal life, consists of a mass of transparent finely granular contractile substance with a nucleus. When movement is taking place a central granular endoplasm and an outer hyaline layer or ectoplasm may be distinguished.

Many authors have described the **Amœba coli** as of constant occurrence in epidemic dysentery. It is present in the stools and in the lesion in the intestine. It is also found in the lesions of the liver, met with as secondary results in dysentery. According to Osler there is not in dysentery a suppurative inflammation such as results from the action of pyogenic microbes, but a progressive œdema and necrosis associated with proliferation of the fixed cells of the tissues. In the liver, also, unless there is an addition of pyogenic agents, there is no proper suppuration—few polymorpho-nuclear leucocytes being present—but rather a necrosis of the liver tissue. The amœba has been observed in epidemics in several countries, in Egypt by Kartulis, in Russia by Lösch, and in America by Councilman, Lafleur, and Osler. (See Dysentery.)

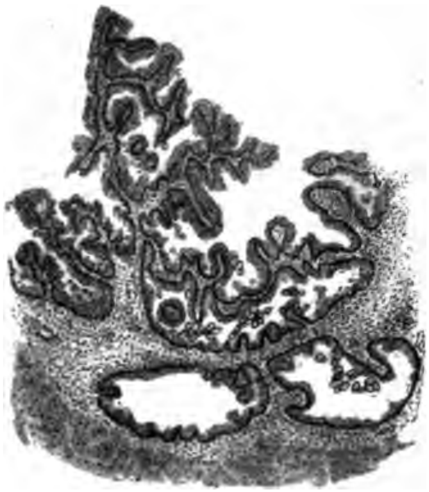


Fig. 231.—Coccidiosis. Liver of rabbit. Dilated bile-ducts with papillomatous ingrowths from wall.

2. **Coccidia. Psorospermia.**—These belong to the class of **Sporozoa**, or unicellular animals with a smooth cuticle. They have little power of movement. These parasites are common in the lower animals, constituting the condition of **Coccidiosis** or **Psorospermosis**, chiefly of the liver and intestine.

Coccidiosis is very frequent in the liver **in rabbits**, both wild and tame. It appears in the form of whitish nodules, often in considerable numbers, which may attain to the size of a hazel-nut. As a large proportion of rabbits is affected, and as it is especially prevalent in the young, the disease is obviously not a very serious one. The white nodules when incised yield a yellow-coloured debris in which innumerable oval bodies are present, the **coccidium oviforme**, which closely resemble the ova of parasitic entozoa. Closer examination shows that the lesions in the liver are related to the bile ducts, and that there is a new-formation of tissue so as to form a cyst with papillomatous projections from its wall (see Figs. 231 and 232). The parasite appears first in the epithelial cells in the form of a small granular body, which grows at first in the substance of the epithelium, distending it as shown in Fig. 232. The parasite finally becomes free and acquires its thick cuticle. These facts are of importance as showing that the presence of this parasite in the epithelium produces new-formation not only of the epithelium, but of the connective tissue, so as to produce a cystic lesion of definite structure. Coccidiosis also occurs in the intestine of some animals. Nocard has described a case in the sheep in which many small tumours in the mucous membrane of the intestine had a structure comparable with that of the coccidial lesions in the liver.

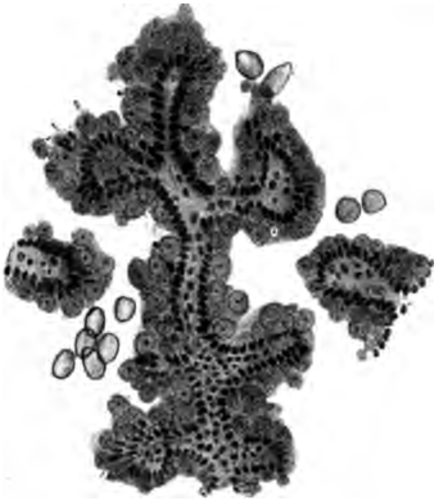


Fig. 232.—Coccidiosis. Liver of rabbit. From same case as Fig. 231. Numerous granular bodies occupy the epithelial cells. Several parasites which have acquired a thick cuticle are seen lying free.

Few cases of a similar nature have been observed in man, but Gubler has related a case in which the liver was the seat of twenty tumours of cancerous appearance, mostly about the size of chestnuts, but one of very large dimensions. The patient died from peritonitis. The tumours were found encapsuled, and contained internally a creamy fluid which presented countless egg-like bodies having the characters of coccidia. A few additional cases have been observed, but not with such pronounced lesions.

Rainey's corpuscles or **Miescher's tubes** are elongated granular bodies found in the muscular substance of some animals—swine, cattle, sheep, and mice (see Fig. 233). The writer has frequently met with them in the muscle of the heart and of the tongue in cattle. They are supposed to be parasitic protozoa—sarcosporidia—but our knowledge with regard to them is still defective. A limiting membrane or capsule is usually easily made out. Within this, in separate partitions, are numbers of rounded, reniform, or sickle-shaped bodies (sporozoites). Although found in many different animals, sometimes in large numbers, they have not been conclusively demonstrated in man.

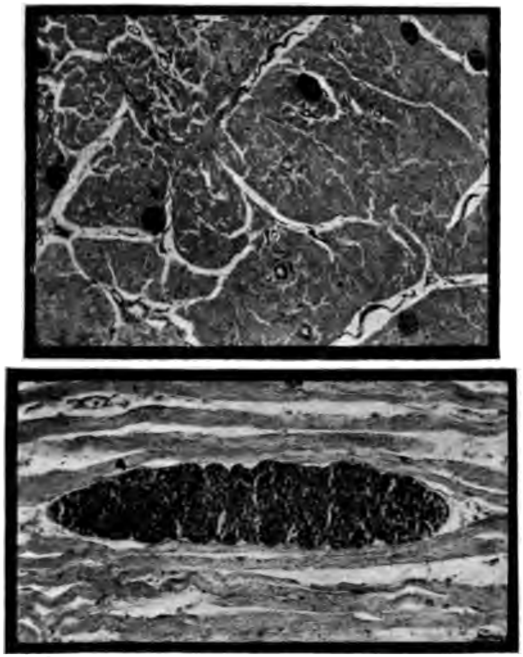


Fig. 233.—Miescher's tubes: Sarcosporidia. From the heart muscle of a cow. The upper illustration shows the bodies in transverse section; the lower in longitudinal section.

Molluscum contagiosum, which from its anatomical characters is also called Epithelioma contagiosum, presents conditions strongly suggestive of coccidiosis. The disease, which is contagious, consists, as shown in Fig. 234, of new-formed epithelial structures continuous with the epidermis. It is a proper epithelial tumour, the little nodules sometimes growing to a diameter of almost half an inch. The more central cells are occupied by bodies which in the earlier or outer zones are in the form of small granular structures, with difficulty distinguishable from the protoplasm of the cells. These bodies grow and push the nucleus aside. Finally they assume a capsule and are converted into oval glancing bodies closely resembling coccidia. These are usually called molluscum bodies. If they be really parasites, then we have here again a tumour-like tissue produced by protozoa. It is to be noted here also that the peculiar bodies are closely associated with the epithelial cells, and, according to many observers, they arise from alterations in these cells.

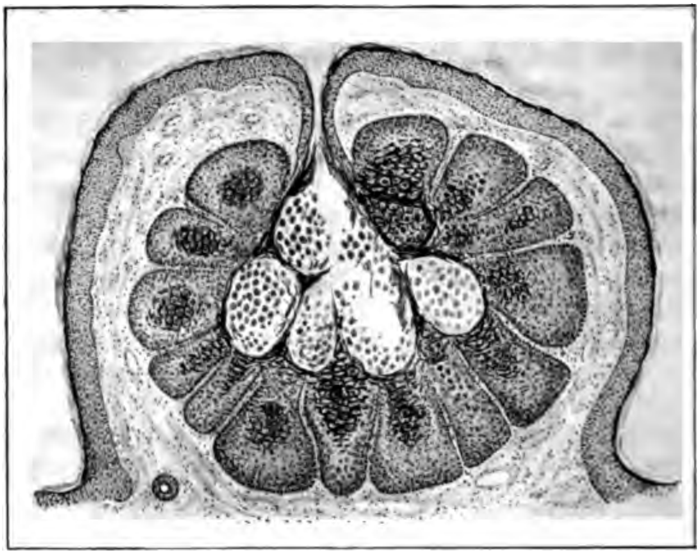


Fig. 234.—Molluscum contagiosum. × 200.

Other diseases of the skin have been found associated with bodies believed to be coccidia or psorosperms. Amongst these is **Paget's disease of the nipple.** The disease is an inflammatory condition of the skin having the usual anatomical features. It has been pointed out by Darier and Wickham that the epithelial cells in this disease contain bodies having the characters of coccidia. It is of importance to note that the disease in question is not infrequently followed by cancer of the mamma, and that similar bodies are also found in the epithelial cells of the cancer.

This subject becomes of importance from the fact that similar bodies have been found in the epithelial cells in cancer, and more recently in the cells of sarcomas. This subject has been already dealt with.

3. Hæmatozoon of malaria, or paludism: Hæmamæba.—This organism will be found fully discussed in all recent bacteriological treatises. Here the briefest possible notice must suffice. The parasite, the knowledge of which we owe in the first instance to Laveran, belongs to the protozoa and to the class of sporozoa, being nearly allied to the coccidia. It has been called, by the Italian observers Marchiafava and Celli, the Plasmodium malariæ, but this name is objected to by Laveran, as the bodies are not plasmodia. The parasite exists in the blood in several forms, which, however, are merely phases of the same organism. The forms described by Laveran are the following:—

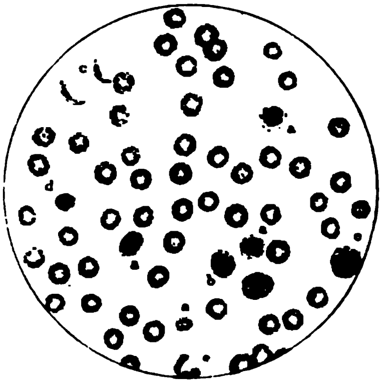


Fig. 235.—Hæmatozoa of malaria in blood, dried and stained. In the midst of normal red corpuscles are seen the following:—*a*, *a*, *a*, *a*, spherical bodies adherent to red corpuscles; *b*, two free spherical bodies; *c*, two crescents; *d*, segmented body; *e*, *e*, leucocytes. (After LAVERAN.) ×250.

(*a*) Spherical bodies.—This is the commonest form. They have the appearance in unstained specimens of small clear spots in the red corpuscles, but take a blue colour with methylene-blue (see Fig. 235, *a*), and they usually have one or more granules of pigment in them. As they grow larger the number of pigment granules increases in them. These spherical bodies are sometimes free in the liquor sanguinis (*b* in figure), at other times attached to red corpuscles, and they evidently live at the expense of the red corpuscles. Under their influence the corpuscles become pale and ultimately disappear, the pigment in the parasites being derived from the red corpuscles. The spherical bodies possess a slow amœboid movement, and they increase by fission.

(*b*) Flagella.—These are found both attached to the spherical bodies and free. The flagella are not pseudopodia of the amœboid bodies, for after formation they free themselves from these. They are very translucent and difficult to observe, unless by their very active movement they cause currents in the blood. This is best seen when they are attached to the spherical bodies. The flagella are thus regarded as in some respects independent bodies, and the suggestion has been made that the spirilla of relapsing fever may be bodies of a similar nature.

(*c*) Crescentic bodies.—These are very definite bodies in the form of crescents with collections of pigment in the central part (Fig. 235, *c*).

A fine curved line is usually seen joining the two extremities of the crescent across its concave aspect. This is probably the remains of a red corpuscle, and the crescent forms at the expense of the corpuscle.

(*d*) Rosette-shaped bodies.—These are spherical bodies, pigmented in the centre and regularly segmented. These are of importance, according to Golgi, as representing the principal mode of multiplication of the parasite.

In addition to these forms of the parasite, leucocytes containing pigment are to be seen. The development of the parasite outside of the human body in its definitive host—the mosquito—will be found fully detailed in bacteriological text-books.

The pathology of malaria fevers is explained by the action of these parasites. Their most obvious effect is destruction of the blood-corpuscles, and this explains the anæmia which is so manifest in malaria. Melanæmia or black pigment in the blood has long been observed in malarial cases, and it finds its explanation in the pigment granules produced by the parasite. The spleen seems to be the organ in which the parasite mostly congregates.

The hæmatozoa sometimes accumulate in the smaller vessels, especially those of the brain, and so produce embolism, which may be of a temporary character. This is the explanation given of certain of the nervous symptoms in malaria. The obstruction may be in the small arteries or capillaries. In prolonged attacks the parasite produces in certain organs the phenomena of chronic inflammation. This is chiefly manifested in the spleen, where there is thickening of the connective tissue, leading to an induration of the organ, the so-called ague-cake. In the acute periods the spleen is enlarged and soft, sometimes diffluent. Chronic inflammations of the liver, kidneys, and lung sometimes ensue.

The blood may be examined for the hæmatozoon either in the fluid state or after drying. The finger of the patient should be carefully washed first with water, then with alcohol, and thoroughly dried. The slide and cover glass should also be thoroughly cleaned. The first drop of blood which appears after pricking should be rejected and a minute drop procured. The cover glass is brought in contact with this, and may be immediately dropped on the slide and examined fresh. The central parts keep fluid for some hours. To obtain dry preparations the cover glass with a small drop of blood is at once placed on another cover glass. The blood spreads out in a thin layer, and the two glasses may be separated by sliding them asunder on the flat. The films quickly dry, and are fixed by passing through the flame of a lamp three times, the film being uppermost. A good way of fixing is to place on the film a few drops of alcohol and ether, equal parts, and allow it to dry (Roux). The dry film may be examined as it is, and may be fixed on a slide with paraffin, or it may be stained with aqueous solution of methylene-blue, or first with an aqueous solution of eosin and then of methylene-blue. It is then examined dry or in Canada balsam.

Hæmatozoa have been observed in some of the lower animals by a number of observers. They have been very fully described in birds (Danilewsky and others). Hæmatozoa appear to be very frequent, and they occur in many different kinds of birds. They have a general resemblance to those in man, but they present such differences from the latter, and also among themselves, as to indicate the existence of many different species of the parasite. In **Texas fever**, a disease of cattle, hæmatozoa have been observed by Smith. This disease is characterized by hæmoglobinuria, and is obviously the same disease as that observed by Babes in Hungary, and described by him under the name Epidemic hæmoglobinuria of cattle. The author finds what he regards as a diplococcus which passes into the substance of the red corpuscles and brings about their destruction. The parasites are mostly in the blood-vessels of the parenchymatous organs, and especially of the kidney. It is not improbable that the parasite here concerned may be a protozoon.

Literature.—L. Pfeiffer, Die Protozoa als Krankheitserreger, 1891; Bütschli in Bonn's Classen u. Ordnungen d. Thierreiches, 1882; Leuckart, Die Menschl. Parasiten, 1886 (Transl. by Hoyle); Kruse in Flügge's Mikroorganismen, 1896; Wasielewski, Sporozoenkunde, 1896. *Amœba coli.*—Lösch, Virch. Arch., vol. lxv., 1875; Kartulis, Centralbl. f. Bakter., ii., 1887, and ix., 1891; Councilman and Lafleur, Johns Hopkins Hosp. Rep., ii., 1891; Osler, Pract. of Med., 1892; Cramer, Centralb. f. allgem. Path., vii., 1896; Janowski, Centralb. f. Bakt., xxi., 1897; Lafleur, Allbutt's Syst. of Med., ii., 1897; Sodré in 20th Century Pract. of Med., xvi., 1899; Davidson, Encyclop. Med., iii., 1900. *Coccidia*—Delépine, Trans. Path. Soc., xli., 1890; Leuckart, Trans. by Hoyle, 1886; Gubler, Report in Davaine, Traité des entozoaires, 2nd ed., 1877, p. 268; Nocard, Journ. of Path., vol. i., p. 404, 1893; Darier, Ann. de Dermat., x., 1889; Wickham, Arch. de path. expér., ii., 1890; Hutchinson, Path. trans., xli., p. 214, 1890; Gilchrist and Kuznitzski, Arch. f. Derm. u. Syph., xxxi., 1, 2. *Hæmatozoa*—Laveran, various papers dating from 1881, and systematic work Paludism, transl. by Syd. Soc., 1893; Marchiafava and Celli, various papers from 1883, and contribution to Festschrift of Virchow, 1891; Golgi, Ziegler's Beiträge, iv., 1889, vii., 1890; Danilewsky, La parasitologie comparée du sang, 1889; Ann. de l'Inst. Pasteur, iv., 1890; Sakharoff, Ann. de l'Inst. Pasteur, vii., 1893; Smith, Sixth and Seventh Reports of the Bureau of Anim. Industry, Washington, 1891; Babes, Virch. Arch., vol. cxv., 1889; Koch, Zeitschr. f. Hyg. u. Infektionskr, xxxii., 1899; Marchiafava and Bignami in 20th Cent. Pract. of Med., xix., 1900; Nuttall (literature), Centralb. f. Bakt., xxv., xxvi., xxvii., 1899-1900. *In Birds*—Danilewsky, Ann. de l'Inst. Pasteur, iv., 1890; Sakharoff, ibid., vii., 1893; Opie (with literature), Journ. of Exper. Med., iii., 79, 1898; MacCallum, ibid., iii., 103, 1898.

II.—TREMATODA. FLUKES.

We have here an order of flat-worms of a more or less oval shape, and many of them somewhat in the form of a leaf. They possess, on the ventral surface, one or more sucking discs by which they attach themselves. They have only one opening of the alimentary canal, which is generally forked. These worms are commonly called **Flukes** from the resemblance in shape of the commonest of them to the fish of that name. The various forms inhabit the bile ducts, except the Distoma hæmatobium, which is found in the veins of the portal system.

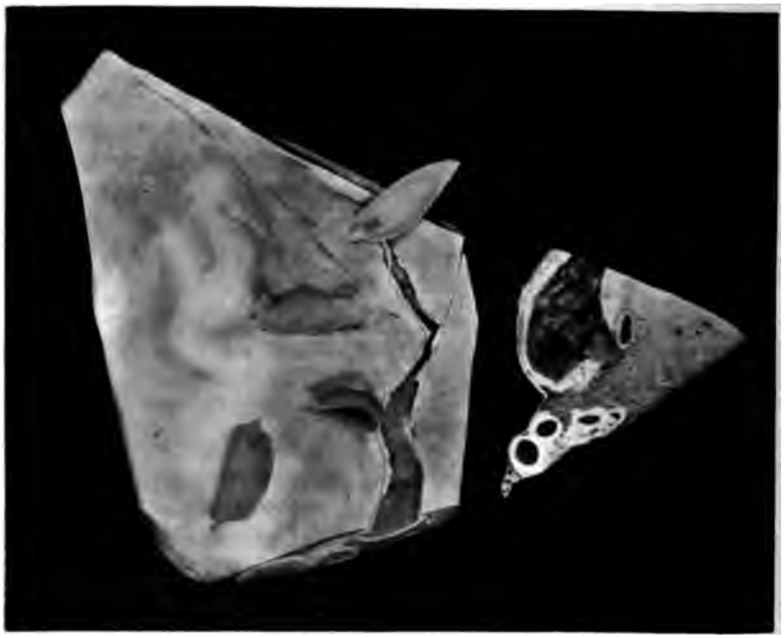


Fig. 236. Distoma hepaticum. Liver of cow. The greatly altered bile ducts are shown. In the smaller illustration they are filled with calcareous matter.

Distoma hepaticum.—This is the commonest worm of this order. As the name implies, it is met with in the liver, where it inhabits the bile ducts (Fig. 236). The liver fluke is generally about an inch in length (Fig. 237) and rather more than half an inch in greatest breadth. The body is very flat, and anteriorly it ends in an elongated process, forming a kind of head. This head bears the mouth, and a short distance behind it comes the sucking disc. Between these lies the opening of the sexual apparatus, both male and female organs existing in each individual. The uterus forms a convoluted tube behind the sexual opening, and the seminal tubules lie still further back. This parasite is very common in certain of the lower animals, especially sheep. It occurs in enormous numbers in the bile ducts, which are dilated by it. As many as 1,000 have been obtained from a single individual. It produces in sheep the disease commonly called the rot, which in some years is very fatal. It is said that in 1830-31 between one and two million sheep perished from it. It occurs also in oxen, where it produces more considerable alterations of the ducts. These become greatly dilated, thickened by inflammation, and encrusted with lime (see Fig. 236). It sometimes happens that masses of inspissated bile and lime salts form in the liver where the flukes are present. It is probable that in these cases many of the parasites have died and become themselves the seat of incrustation. This fluke has also been met with in horses and asses, and in some rare cases in man. In man it has not been observed in large numbers, but it may produce serious obstruction of the bile ducts.

Fig. 237.—Distoma hepaticum. The larger is viewed from the ventral, the smaller from the dorsal aspect. Actual size.

The eggs of this parasite are small oval bodies, which, in water, develop into embryoes which swim about by the aid of cilia. The intermediate host of the distoma hepaticum, which long eluded observation, is now known to be a small gasteropod possessed of a thin spiral shell, the *Limnæa truncatula*. This mollusc, the shell of which only measures about 1 cm. in length, is almost cosmopolitan in its distribution.

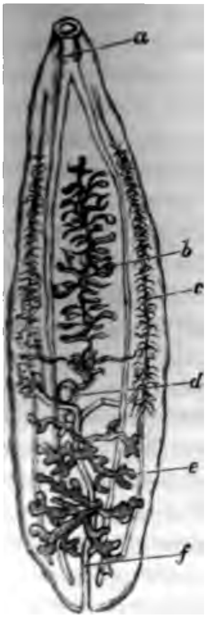


Fig. 238.—Distoma sinense: *a*, œsophagus and stomach tubes; *b*, uterus; *c*, yolk glands; *d*, ovary; *e*, testes; *f*, termination of water vascular system. × 3. (After MACGREGOR.)

Distoma lanceolatum.—This form of fluke is less than three-eighths of an inch in length, and about the fifteenth of an inch in breadth. It is seldom seen in man, occurs in comparatively small numbers in sheep and cattle, and produces little disturbance.

Distoma sinense or **spathulatum.**—This parasite has been met with in the East, and described by M'Connell in the *Lancet* in 1875, and independently by Macgregor in the *Glasgow Medical Journal* in 1877. It is a much smaller worm and is of a more elongated shape than the distoma hepaticum, as will be seen from Fig. 238. It is rather more than half an inch in length, and about an eighth of an inch in greatest breadth. When seen in the bile in the fresh state the edges show a beautiful delicate green colour, tinged with yellow, while the centre is of a deep brown. In the accompanying figure the position and appearances of the various organs are indicated. The eggs are very small, each animal possessing thousands. This parasite is of very frequent occurrence in China and Japan, especially the latter, where it constitutes a serious malady. It is found in very large numbers in the bile ducts and gall-bladder, and produces symptoms like those produced in animals by the distoma hepaticum. The liver enlarges and becomes painful, and there is a gradual loss of strength and nutrition. Later, diarrhœa, ascites, œdema of the feet, and general cachexia result.

Distoma pulmonale or **Ringeri.**—This is also a parasite prevalent in Japan. According to Manson it is present in 15 per cent. of the inhabitants of Formosa. It is a short, plump worm about 1 cm. in length; the transverse section is nearly circular. It is found in the lungs enclosed in little capsules formed of connective tissue. It gives rise to cough and hæmoptysis. In the sputum the eggs of the worm are present sometimes to the number of several thousands daily. A case has been recorded by Yamagiwa in which the ova of this parasite produced embolism of the brain with symptoms of Jacksonian epilepsy.

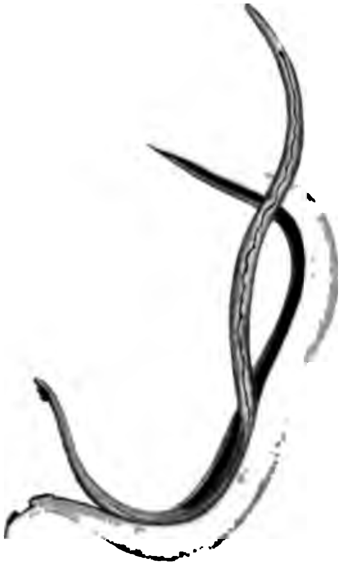


Fig. 239.—Bilharzia hæmatobia. Adult male and female. The female is lying in the gynæcophoric canal.

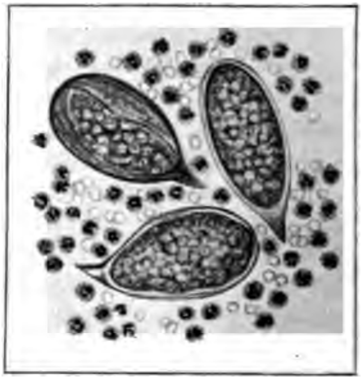


Fig. 240.—Ova of Bilharzia hæmatobia. From the urine. × 200.

Distoma hæmatobium.—This parasite, also called the Bilharzia hæmatobia, has the male and female organs in different individuals (see Fig. 239). The male is about half an inch in length, and flat, but rolled up at the edges, especially behind, so as to form a kind of gutter—the gynæcophoric canal—in which the female lodges. The female is about a half longer, but filiform. The eggs are small and furnished with a spine at the end or at the side (see Fig. 240).

The parasite inhabits the blood-vessels of its host, chiefly the portal vein, the splenic and mesenteric veins, and those of the rectum and bladder. The ova penetrate the walls of the vessels as shown in Fig. 241, which is a photograph from the portal vein. The penetration of the eggs in large numbers into the mucous membrane of the rectum and urinary bladder produces great irritation and may lead to definite tumour formations. Hæmorrhage, from the rectum or bladder, is a frequent symptom. Similar irritation may be produced in the pelvis of the kidney and ureters. The eggs are found often in large numbers in the bloody discharges from the intestine and in the urine. This parasite is met with in Egypt and Abyssinia, and it is said that in Egypt about half the natives are victims of it. During the recent war in South Africa a considerable number of our soldiers contracted the disease.

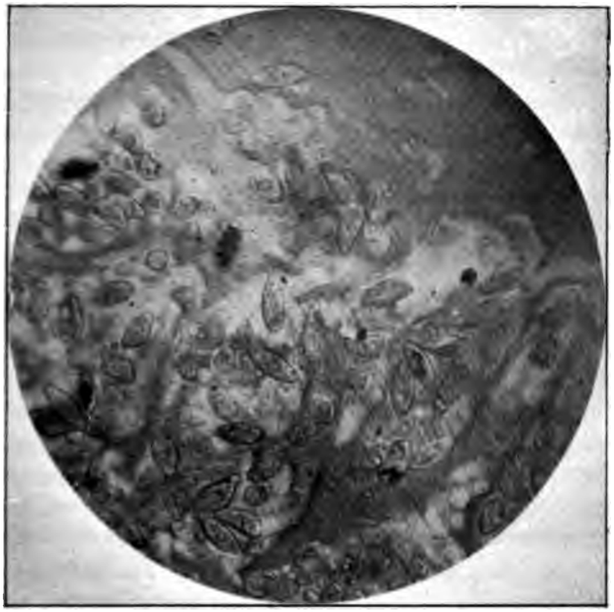


Fig. 241.—Ova of Bilharzia hæmatobia in the wall of the portal vein. × 60.

Literature.—Leuckart, in general. *Distoma hepaticum*—Weinland, Arch. f. Naturgeschichte, ii., 1874; Thomas, History and full account, Quar. Jour. of Mic. Sc., 1883. *Human Distomata*—M'Connell, Lancet, 1875; Macgregor, Glas. Med. Jour., 1877; Baelz, Berl. klin. Wochenschr., 1883, Die Krankheit. d. Athemorgane,

Tokio, 1890; Yamagiwa, Virch. Arch., cxix., 1890; Manson, Med. Times and Gaz., 1881 and 1882; in Allbutt's Syst. of Med., ii., 1897; Guillemard, ibid., ii., 1897. Peiper, Lubarsch and Ostertag, Ergebnisse, iii., 1897. Huber, 20th Cent. Pract. of Med., viii., 1897. Ritchie, Encyl. Medica, ix., 1901.

III.—CESTODA. TAPE-WORMS.

These are in the mature state long flat worms, without mouth or alimentary canal. Anteriorly there is a **head** furnished with some apparatus for attaching itself to the host. Behind the head and neck are a series of segments called **Proglottides**, each of which develops a bi-sexual apparatus, and is, so far, a complete individual. The adult worm or **Strobilus** is therefore a colony of individuals. The worm inhabits the alimentary canal, and apparently occurs only in vertebrate animals. Besides this adult form there is an intermediate immature form, called the **Scolex**, which occurs in the tissues of animals. The scolex has a head like that of the mature worm, and generally possesses a sac or cyst into which it can retire. In the case of many of the tape-worms the scolex form has been described independently of the adult, and often in ignorance of the connection, under the name of **Bladder-worms**. There is thus a bladder-worm for each tape-worm. The bladder-worms of the various tape-worms are divisible into three principal forms, namely, **Cysticercus**, in which each cyst has a single head, and is therefore small in size (see Fig. 242); **Cœnurus**, in which the bladder, although single, develops several heads (see Fig. 243); and **Echinococcus** or **hydatids**, in which there are complicated vesicles, and the heads are grouped inside secondary cysts.

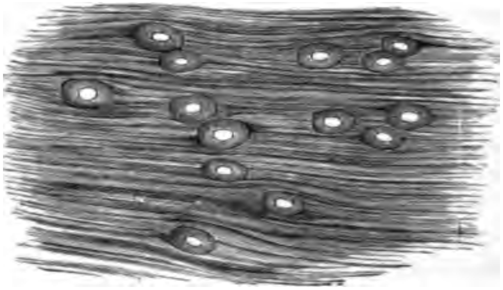


Fig. 242.—Cysticerci of tænia solium in muscle. Natural size. (Leuckart.)

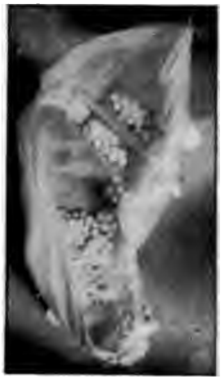
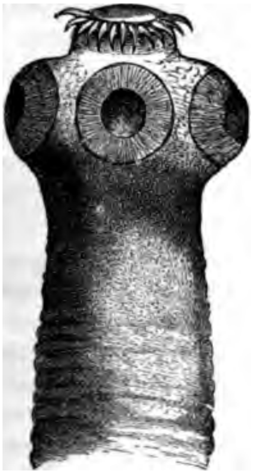


Fig. 243.—Cœnurus of tænia serialis from peritoneal cavity of a rabbit. Many heads in a single cyst. (Natural size.)

There are representatives of two families of tape-worms met with in man, namely, Tænia and Bothriocephalus. To prevent repetition, the general anatomical features will be somewhat fully given in the description of the form taken first.

1. **Tænia solium.**—This form is of very common occurrence in this country, but that taken next is probably as frequent, if not more so. The strobilus or mature worm occurs in the alimentary canal, and the head is usually situated in the duodenum or upper part of the jejunum, while the rest of the animal extends downwards in the canal, attaining on an average a length of from ten to twelve feet. As already mentioned, this, like other tape-worms, has no alimentary canal, and supports itself by imbibition of nutritious material from the intestine.



. Fig. 244.—Head of T. solium × 45. (LEUCKART.)

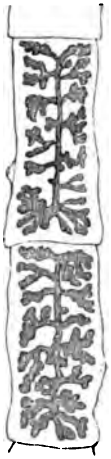


Fig. 245.—Two ripe proglottides of T. solium, with branches of uterus shown. × 2. (LEUCKART.)

The head of the worm, which is represented in Fig. 244, is about the size of a pin's head, and of a generally rounded form. In front it is prolonged so as to form a proboscis or rostellum, which is surrounded by a circle of twenty-six hooklets, which are alternately larger and smaller (see Fig. 244). The wide part of the head has four large sucking discs. On the head follows a narrow neck, which is so thin that it readily breaks when the worm is handled, rendering it difficult to obtain the small head. The proper neck is about half an inch in length, and it gradually merges in the anterior part of the body, in which fine transverse lines begin to appear as the first indications of the formation of segments. On passing down, the worm increases in breadth, while the segments elongate and become more completely divided. At first the segments or proglottides are homogeneous in appearance, but by and by the sexual apparatus begins to appear. The total number of segments in a worm ten feet in length is about 800. The sexual apparatus begins to appear about the 200th segment from the front, and is mature about the 450th; it consists of the male and female organs, which are present in each segment. In the fully matured segment the ova are visible, and when a proglottis is dried on a glass slide they indicate the form of the uterus, which in this tapeworm consists of a central stem and ramifying lateral branches to the number of seven to ten (see Fig. 245).

The male organs consist of a large number of vesicles scattered throughout the segment, as shown in Fig. 246, but more abundant anteriorly, as the female organs occupy the space behind. The vesicles are connected with fine seminal tubules, which are difficult to make out, and are shown in the figure as fine branching lines. These end in a slightly convoluted tube, the vas deferens, which is generally very distinct, and this passes across the segment to the papilla, a slight projection at the side of the segment into which the male and female sexual organs open. At the papilla the vas deferens ends in a projectile penis, which is capable of passing into the extremity of the female organ, the first part of which is called the vagina.

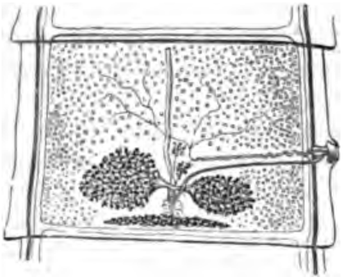


Fig. 246.—Unripe proglottis of T. solium showing sexual organs. The small vesicles scattered throughout are the male organs. The other structures shown are seminal tubes, vagina, globular body, yolk body, ovaries, and unbranched uterus. × 10. (LEUCKART.)

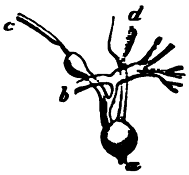


Fig. 247.—The globular body, or Mellis's body and its connections. See text. × 30. (LEUCKART.)

The vagina forms a canal which passes transversely across the segment towards the middle line and tends also backwards, to end in a somewhat globular dilatation, sometimes called the **Globular body** or shell-gland, or Mellis's body. The connections of this body are difficult to make out, but they may be stated as follows, and understood by the annexed Figs. 246 and 247. In the posterior part of the segment, as shown in Fig. 246, are seen on either side the comparatively large ovaries, forming tree-like expansions, consisting of a congeries of closed tubes. The ovaries have ducts which pass into the globular body. Behind the ovaries and the globular body is the yolk gland, which is of a somewhat pyramidal shape and spread out laterally. This also communicates with the globular body in front of it. Besides these communications the globular body, which is thus the central part of the female organs, communicates with the uterus in front. At the period of development shown in figure the uterus consists of a simple tube extending longitudinally in the middle of the segment. It will thus be observed (Fig. 247) that the globular body has communication with four distinct structures, *a* with the yolk-sac, *b* with the ovaries, *c* with the vagina, and *d* with the uterus. The eggs pass from the ovaries first into the globular body, where they receive a covering of yolk, are fertilized, and undergo the beginning of their development. Then they pass into the uterus, which they fill up. As the ova accumulate in the uterus, this begins to throw out lateral branches to the number of seven to ten (see Fig. 248). The lateral branches often show considerable ramifications in this respect, and in their number contrasting with those of the next tape-worm. In the fully mature proglottis only the uterus crowded with ova is visible, the remaining organs having disappeared (see Fig. 245). The prominent ova often make the position and shape of the uterus very distinct, especially if the proglottis be spread out on a glass slide and allowed to dry.

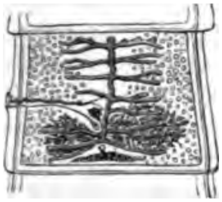


Fig. 248.—Proglottis of T. solium, showing branching of uterus. × 5.

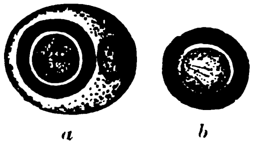


Fig. 249.—Ova of T. solium, *a*, with yolk; *b*, without yolk, as in mature segments. The hard brown shell is indicated. (LEUCKART.)

Besides the sexual organs the proglottides possess **muscular fibres**, and a **water-vascular system**. The muscle is non-striated, and consists of longitudinal and transverse bundles. The water-vascular or excretory system (shown in Figs. 246 and 248) is in the form of tolerably wide channels, which begin at the head and are continued through the proglottides by two lateral channels right down to the last, where they open outwards. Near the posterior extremity of each proglottis the tubes form transverse communications (see figures). It is possible to inject these tubes from above downwards, but not from below upwards. In addition, the proglottides, as well as the head of the worm, possess numerous round or oval calcareous bodies, which are mainly in the superficial layers of the parenchyma.

As the **proglottides** become mature they sever their connection with the worm and drop off from its lower extremity one by one. They pass down the alimentary canal, and are discharged with the fæces, or else work their way out through the anus by virtue of their contractile power. For a short time after discharge they still show a writhing movement, but they soon come to rest and die. By the decomposition of the proglottis the ova are set free and are ready under suitable circumstances to develop further.

It is mostly in the bodies of swine that the tænia solium passes through the next phase of its development, although sometimes it occurs in man.

The Ova (Fig. 249) are surrounded by a dense shell of a brownish colour. Inside the shell the egg develops an embryo which acquires six boring spines. When such ova get into the intestinal canal of the pig, the shell bursts, and the embryo with its spines escapes. It proceeds to bore its way outwards, and after piercing the alimentary canal, it finds its way to the muscles of the animal where it finds a lodgment.

Arrived at its desired seat, the embryo comes to a state of rest, and after a time develops into the scolex, or **Bladder-worm**, which is, in the case of this species, called the **Cysticercus cellulosæ**. The appearance of these cysticerci in the muscular tissue is shown in Fig. 242, which is drawn of the natural size. The complete cysticercus or scolex is composed of a sac, connected with which is a head, which closely resembles the head of the mature worm, and possesses similar hooklets (Figs. 250 and 251).

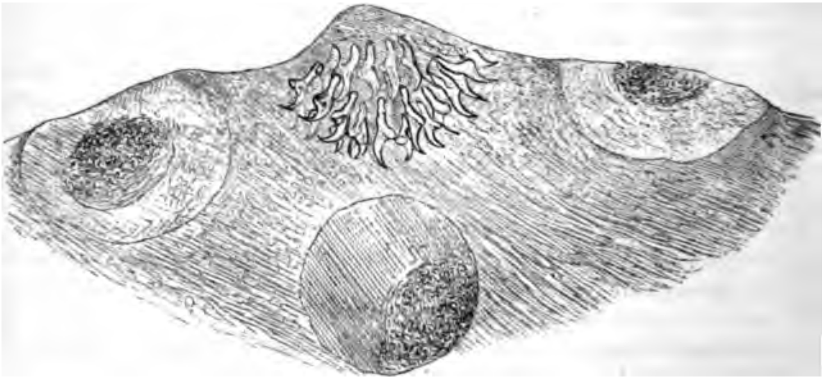


Fig. 250.- Head of cysticercus cellulosæ found in substance of brain. × 90.

The **Cysticercus cellulosæ** occasionally develops in the human subject. It occurs chiefly in the brain, in the eyeball, and in muscle. In rare cases the cysticercus assumes in the brain a very peculiar character. The cyst, developing in the membranes on the surface of the brain, presents pouches and swellings which give it somewhat the character of a bunch of grapes, and so has arisen the designation **Cysticercus racemosus**. Heads are seldom found in these bunches, and at most there is but one, which has the characters of that of the tænia solium. The cysticercus is usually surrounded by a connective-tissue capsule which is produced from the surrounding tissue and encloses both cyst and head, but not infrequently, especially in the brain and eyeball, it is devoid of this secondary capsule. In that case the vesicle sometimes grows to considerable dimensions, and the head is able to protrude itself and move about in various directions, perhaps in the ventricle of the brain or the eyeball. In these parts the scolex may produce considerable disturbance.

Although capable of a considerable duration of life, after a time the scolex usually dies, and then it shrinks and becomes, probably, incrusted with lime salts.

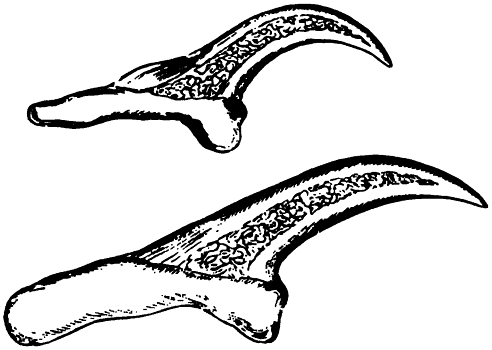


Fig. 251.- Hooks from head of cysticercus cellulosæ. × 350.

The observations of Leuckart and others have thrown much light on the development of the scolex, as they are based on actual experiments in which swine were fed with the ova.

In the first place a vesicle or cyst is formed in the muscle. After a time a slight thickening of the wall of the cyst appears. This grows inwards into the cyst, carrying with it, however, the external wall, so that the projection inwards is hollow with an internal canal continuous with the external surface of the cyst, and so opening externally; this is shown in Fig. 252, where a portion of the wall of the cyst is preserved, and the projection is shown with its internal cavity communicating with the surface of the cyst. This projection enlarges, and by and by the peculiar structures of the head, namely, the four sucking discs and the hooklets, show themselves. But these are formed inside the canal, near its inner extremity, and they are in an inverted position as compared with those of the mature tape-worm. The head with its hooklets is thus at the bottom of the canal, and the four suckers, looking towards each other, follow. After a time the head acquires the power of inverting itself outwards, and thus projecting from the vesicle, or again withdrawing itself within the vesicle as before. This is effected by means of muscular fibres. For the completion of this phase of development a period of from three to four months is required from the time of the ova being taken into the alimentary canal.

When living scolices are taken into the alimentary canal of man, in the first place, the vesicle and everything but the head and neck are lost, and we have a small creature which has considerable power of elongating and moving about its suckers, as shown in Fig. 253. The head now fixes itself to the wall of the alimentary canal, and the body begins to develop from its posterior extremity. It takes eleven or twelve weeks for the worm to assume its full dimensions, and at the end of that time it begins to shed proglottides. The worm is of tolerably long life, and may inhabit the intestine of its host for many years. It not infrequently happens that several co-exist in the same person; as many as 30 or 40 have been observed.

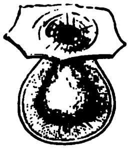


Fig. 252.—Cysticercus with beginning of development of head. A portion of the original cyst is shown with the projection inwards of a hollow process which communicates externally. × 25. (LEUCKART.)

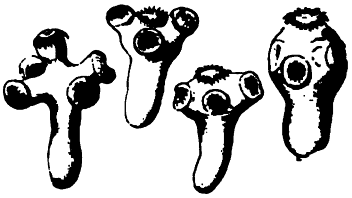


Fig. 253.—A single head of tænia solium before segmentation has begun. It shows movements of its suckers, etc. × 25. (LEUCKART.)

2. **Tænia mediocanellata** or **saginata.**—This worm has a strong resemblance to the tænia solium, and in Britain it is probably more common than the latter, this being connected with the beef-eating character of our countrymen.

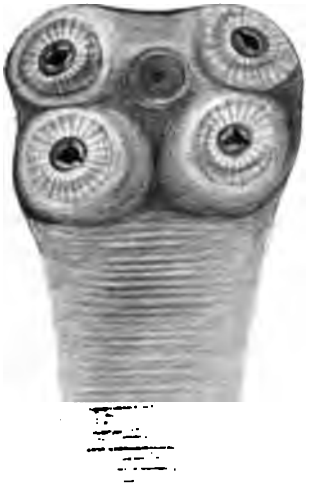


Fig. 254. Head of tænia mediocanellata. × 16.

The strobilus is a larger worm than the tænia solium, measuring from about thirteen feet in the contracted state to about twenty-four feet when extended. Fig. 254 shows the head and neck of this worm. The head has no rostellum or circle of hooks, but it possesses four large sucking discs which are usually surrounded by zones of pigment. In the greater part of the worm the segments are broader than they are long, attaining a breadth of about half an inch. But as we come to the fully mature proglottides with embryoes in the uterus, then they are considerably elongated and at the same time narrower. The number of segments is greater here than in the tænia solium, reaching as high a figure as 1300. There are generally about eight discharged from the posterior extremity daily, and these very often find their way outwards, through the anus, by their own movement. The worm may live for many years, at least as long as eleven, and, as some assert, up to twenty or even thirty years.

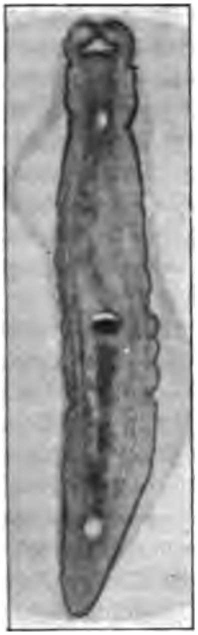


Fig. 255.—Transverse section of proglottis of tænia saginata. At the upper end is the genital pore. Beneath it is the water-vascular canal. In the middle the central stem of the uterus is shown. × 8.

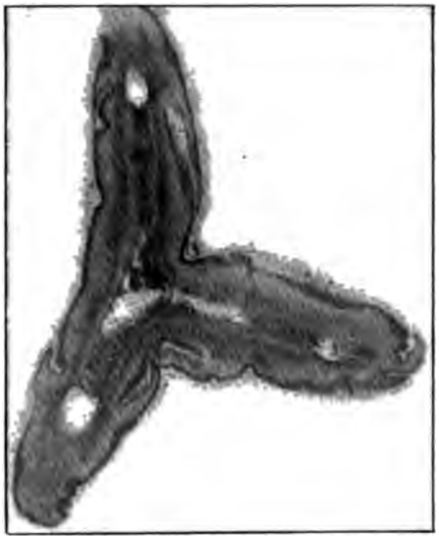


Fig. 256.—Prismatic malformation of tænia saginata in transverse section. There are three equal limbs. The uterus has a common stem in the middle. The water-vascular canals are seen in section near the end of each limb. × 8.

The sexual organs, except the uterus, are essentially the same as in the tænia solium. The uterus, however, presents in the mature proglottis a much larger number of lateral offsets, as many as twenty to thirty, and these mostly branch dichotomously instead of ramifying.

This tape-worm, is liable to certain **malformations**, such as supernumerary joints inserted irregularly between the normal ones. The most peculiar malformation is the **prismatic variety** of the worm, shown in cross section in Fig. 256. In this form the worm is not a flat band but a more substantial body, with three projecting borders. The structure is similar to that of the ordinary form, and the sexual pore is at the extremity of one of the projections. (See case by author in Glas. Med. Jour., xxxv., 1891.)

The scolex form of this worm is found chiefly in cattle, and is hence sometimes called the **Cysticercus bovis.** It inhabits mostly the muscles, but is also met with in other organs. The cysticercus measures about the third of an inch, and is of a roundish shape. It is not known to occur in man.

3. **Tænia echinococcus.**—In the strobilus form this is a comparatively insignificant worm (Fig. 257). It inhabits the dog, and there are generally several individuals present at the same time. The total length of the worm is about an eighth of an inch, and it consists only of four segments, including that which carries the head. In the fully developed state the last segment exceeds in length the rest of the worm altogether (see figure). The head is like that of the tænia solium in miniature, being very much less in size. It has a rostellum with thirty to forty hooklets, and four sucking discs. The last segment develops a large number of eggs—as many as 5000.

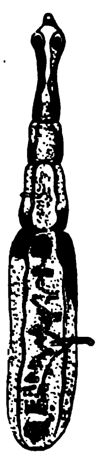


Fig. 257.—Adult tænia echinococcus. × 12. (Leuckart.)

These eggs develop the usual embryoes with six spines, and if they find their way into the intestinal canal of man, they pass out into the tissues. Settling in some organ of the body, they show the most extraordinary powers of development, producing the condition commonly called **Hydatids.**

Hydatids occur in the form of large cysts, often of very complex arrangement, and they should be carefully distinguished from the cysticerci, which form small cysts not more than half an inch in size. The hydatids occur in the majority of cases in the liver. Neisser has collected no less than 986 cases of hydatids in man, and he gives the scale of frequency in the different organs as follows: Liver, 451; lungs and pleura, 84; kidneys, 80; muscle and subcutaneous tissue (including the orbit), 72; brain, 68; spinal cord, 13; female organs of generation (including the mamma), 44; male organs, 6; pelvis, 36; organs of circulation, 29; spleen and bones, 28; eye, 3. Finsen found in Iceland that the lungs were affected only in 3 per cent. of the cases.

When the embryo reaches the liver or other resting-place, it soon develops into a cyst which at first is of slow growth. The membrane of the cyst is of considerable thickness, and consists of an external stratified cuticle (the ectocyst), and an internal parenchymatous layer containing muscular fibre and a vascular system (the endocyst). Inside the original vesicle arise very frequently *secondary* vesicles, and inside these even tertiary ones, the successive vesicles being sometimes spoken of as daughter or grand-daughter vesicles. It sometimes happens that the secondary vesicles project outwards, and form a series of external vesicles which may separate from their mother and attain an independent development alongside of her. This latter form is particularly common in the domestic animals, and it is variously designated **exogenous hydatids**, and **echinococcus scolecipariens** or **granulosus**. Hydatids in bone usually assume the form of exogenous cysts (Targett). There is a third or **alveolar** form which has been met with in man, and always in the liver. In it the parasite develops a congeries of small vesicles, from the size of a grain of wheat to that of a pea. These are embedded in a gelatinous matrix and sometimes possess gelatinous contents. As the whole is surrounded by a firm fibrous capsule, the tumour is a somewhat solid one, and on section presents a peculiar alveolar appearance. This should be particularly borne in mind, as the condition has been frequently mistaken for a tumour, especially before Virchow demonstrated its true nature.

Except in the case of the alveolar form, the vesicles, both primary and secondary, enlarge very much and give rise to tumours of very large dimensions, so as sometimes to produce serious disturbance by their mere size. Those of the liver are usually the largest, and they may come to weigh as much as twelve, twenty, or even thirty pounds. The simple vesicles, in which no daughters develop, attain the size of an orange or a fist.

In all forms of hydatids the whole parasite is surrounded by a fibrous capsule, developed by the organ in which it has its seat. As the cysts enlarge, this also increases in size.

The formation of the heads of the worms differs in certain respects from that of the other tæniæ. In the walls of the vesicles, either primary or secondary, are to be seen, when they are perfectly fresh, a number of small white points which have their seat in the internal wall. These are not the heads but the **Brood-capsules** or proligerous vesicles in the walls of which the echinococcus heads grow.

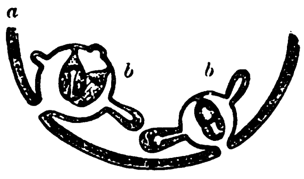


Fig. 258.—Diagrammatical illustration of development of echinococcus heads in brood-capsules. *a*, Wall of cyst; *b*, *b*, brood-capsules, with heads in various stages of development. (LEUCKART.)

The heads begin (see Fig. 258, in which the development of heads in brood-capsules is shown) as projections outwards of the wall of the brood-capsule. The projection is hollow, and communicates with the interior of the brood-capsule. The head develops inside this projection, as in the case of the tænia solium, and very soon acquires the power of inverting itself. When it does so, it projects into the brood-capsule, so that in this respect the brood-capsule is not like the cyst of the cysticercus, as the scolex projects outwards from the latter. A single brood-capsule develops several heads—up to twelve—and they may be found either in the extended or inverted position. All the heads are contained in brood-capsules, but if after death or during removal the brood-capsule bursts, then an appearance may be produced as if the heads were attached to the wall of the cyst itself. If the capsule burst, its remains may gather round its stalk and the heads stand up from this as in Fig. 259, *b b*. Heads may also be found lying free if the capsules have burst. It is to be added that sometimes the vesicles remain barren, neither brood-capsules nor heads developing in them. These are the so-called **Acephalocysts.**

It is an interesting fact, that although the bursting of a hydatid cyst or the drawing off of its fluid generally causes the death of the parasite, after rupture, the parasite, passing into the peritoneal cavity may live as minute vesicles, or grow so as to produce cysts as large as the fist.

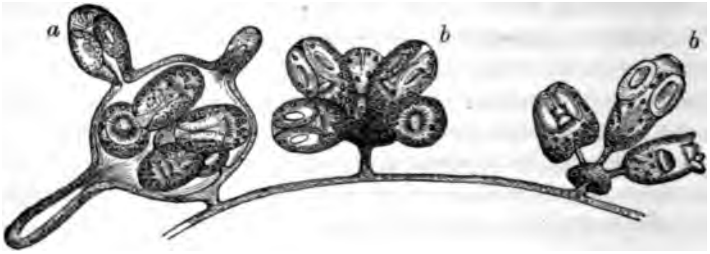


Fig. 259.—Brood-capsules in connection with walls of vesicle. *a*, A capsule in normal unruptured state; *b*, *b*, ruptured capsules. × 40. (LEUCKART.)

The heads which are formed in vast numbers are exactly like those of the mature worm (see Fig. 259). They are very minute objects, measuring about $\frac{1}{70}$th of an inch in their long diameter, and are just visible to the naked eye. They possess a proboscis with a ring of hooklets, and four suckers. They are also provided with a water-vascular system, and in their parenchyma abundant calcareous particles are to be found.

Dead and shrunken hydatids are more frequently met with in this country than active ones. The animal may die spontaneously, or be killed by the fluid which fills the vesicles being drawn off. In that case the vesicles shrink, and their contents become converted into a fatty debris, which afterwards may become infiltrated with lime salts. In this way the hydatid mass may be represented by a cyst filled with atheromatous material (see Fig. 260). This may dry-in, and at last we may have nothing left but a stony or mortarlike mass, in which careful search may still discover calcified heads and hooklets (Fig. 261). Besides the distinctive hooklets, or even without them, there are usually in these old cysts portions of the chitinous membrane or cuticle of the parasite. (See Fig. 262, in which by shrinking of the whole

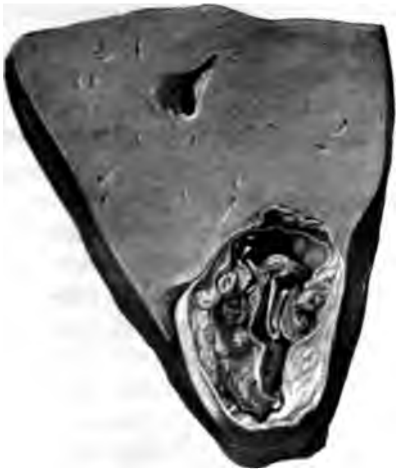


Fig. 260.—Portion of liver with collapsed and calcified hydatid cyst. Natural size.

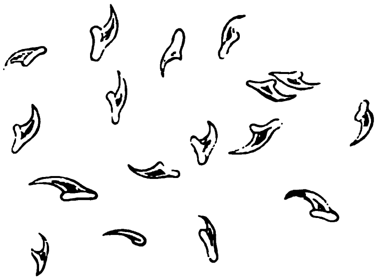


Fig. 261.—Hooks from tænia echinococcus. × 350.

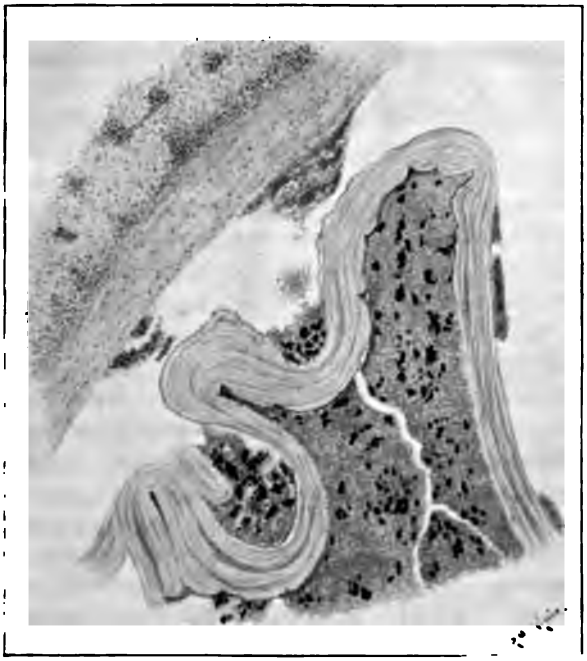


Fig. 262.—From a shrunken hydatid of the liver. To the left is liver tissue, which is separated from the lesion by a broad band of connective tissue. Within this is the stratified membrane of the parasite, variously folded. The black spots are dead and calcified heads of the parasite. × 8.

lesion, the stratified chitinous membrane has been thrown into folds. The dead and calcified heads are also shown as opaque bodies.) As this chitinous membrane is very resistant it may be found in the midst of the grumous contents and enable the structure to be recognized. In some cases the diagnosis is made chiefly by flakes of this membrane being found, the search for hooklets being in vain.

In regard to the distribution of the echinococcus, it is of pretty frequent occurrence in all known lands, but it is particularly common in Iceland, where the men, living in close companionship with the dogs, are much exposed to infection. It is also very common in Australia and the neighbouring colonies.

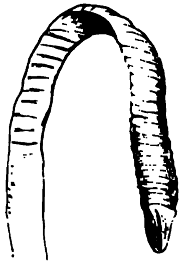


Fig. 263. — Head and portion of body of Bothriocephalus latus. × 8. (LEUCKART.)

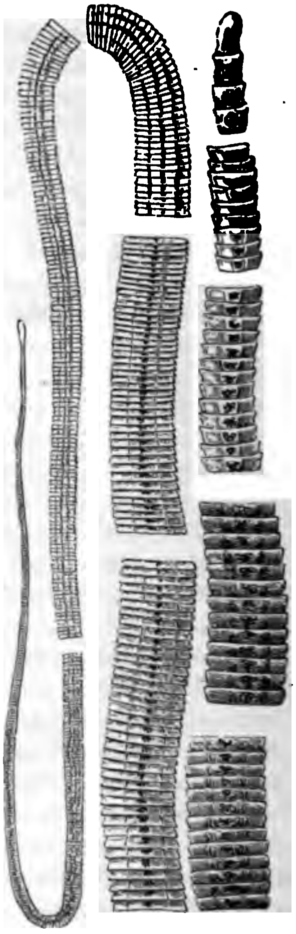


Fig. 264. — The Bothriocephalus latus. Natural size. (LEUCKART.)

Bothriocephalus latus.—This is the largest tape-worm which occurs in man. It attains a length of from 16 to 26 feet, and possesses from 3,000 to 4,000 segments, which are mostly much broader than long, although the last ones (see Fig. 264) become longer and narrower so as to assume more of a square shape. The breadth at the widest part is about half an inch. The worm is also thick and heavy.

The head (Fig. 263) is oval, and about the twenty-fifth of an inch in breadth. It is blunt at the extremity, and possesses neither hooklets nor suckers, but fixes itself by means of a slit-like groove on either side of the head (see figure).

The sexual organs, and especially the uterus, occupy the middle part of each segment, where they form a rather prominent knot or rosette

(Fig. 265). The uterus is composed of a convoluted tube, which gives the rosette-like appearance just mentioned. The sexual organs open in the middle line near the anterior extremity of the proglottis. The eggs are oval in form, and are covered by a brown shell.

This worm is rarely met with in Britain. It is frequent in Sweden, Russia, Switzerland, and Japan. It is specially in fish-eating districts that it occurs.

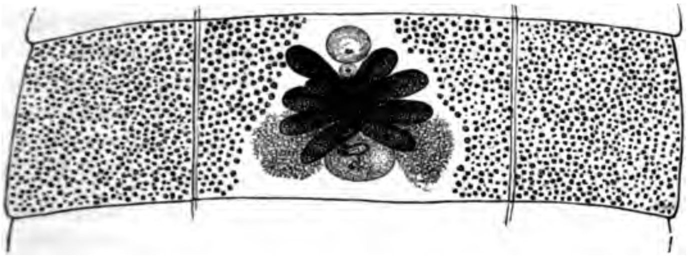


Fig. 265.—Proglottis of Bothriocephalus latus, showing female organs. × 12. (LEUCKART.)

The scolex form of the worm long eluded observation. It was known that a six-spined embryo formed in the eggs in the usual way, but the habitat of the cysticercus was unknown. Braun has finally demonstrated its existence in the pike. In some localities every individual pike contains many scolices. It has also been found in some other fish. It was found in the muscles, sexual organs, liver, spleen, etc., of these fish. Braun proved that it was the scolex of this animal by feeding dogs with it. A tape-worm identical with the bothriocephalus developed.

This worm is of rather frequent occurrence in Switzerland and north-east Europe, but it is not unknown in this country. The frequency of fresh-water lakes in Switzerland explains its common occurrence there, the fish, which form the hosts of the scolex stage, being used as an article of diet. Like the other tape-worms, the mature worm occurs in the small intestines.

Several other small and infrequent tape-worms have been met with in man.

The **Tænia nana** has been observed in Egypt and Italy. It is very small, scarcely an inch in length, and about the fiftieth of an inch in breadth. It possesses a rostellum with hooklets and four sucking discs.

Tænia flavopuncta.—It has been observed a few times in children in America and Italy. It is about a foot in length, and about one-twentieth of an inch in breadth. The head has been described by Parona as devoid of hooklets.

Tænia Madagascariensis.—This form has been found in an island on the Madagascar coast. It is about three inches long, and the head is not yet known.

Tænia cucumerina.—This worm is from 7 to 10 inches long. Its head possesses a rostellum with a quadruple circle of hooklets to the number of about 60. These are somewhat like the spines of a bramble bush in shape, and dotted over the protruding rostellum, give a curious appearance. The proglottides reach a breadth of about the twelfth of an inch. It is almost constantly present in dogs and cats, and often in large numbers, especially in dogs. It has been found in several cases in man, and it seems to be not infrequent in children. The scolex form has lately been found in the dog-louse (Trichodectes canis), and it can be readily understood how in the process of licking itself the dog often swallows the parasite, and becomes itself the host of the strobilus. It may be conveyed to children from the tongue of the dog.

The **lower animals** are much affected with tape-worms, either in the adult or scolex form. The dog in particular accommodates a number of forms in the intestine, and each of these has its appropriate intermediate host for the bladder-worm. Besides the Tænia cucumerina, mentioned above, the following parasites of the dog may be mentioned:

Tænia marginata.—This is a tape-worm of large size, its usual length being about 5 feet. It is very like the tænia solium, but smaller, the head possessing a rostellum with 30 to 44 hooklets. The scolex form, or **Cysticercus tenuicollis**, inhabits swine and the ruminants, and it often develops large vesicles in the peritoneum.

Tænia serrata.—A large tape-worm about a yard long, possessing 34 to 38 hooks. Its intermediate host is the hare or rabbit, where it occurs in the peritoneum as the Cysticercus pisiformis.

Tænia serialis.—This tape-worm is half to three-quarters of a yard long. Its head has 26 to 32 hooks. Its scolex form is chiefly found in the peritoneum of rabbits, where it forms a cœnurus, that is to say, a bladder with many heads inside it (see Fig. 243). In this form it is called **Cœnurus serialis.**

Tænia cœnurus.—This is like the preceding, but larger. Its head possesses 22 to 32 hooks. The intermediate form is found in the brain of sheep (exceptionally in that of the calf, as in case observed by the author), and is a cœnurus—the **cœnurus cerebralis.** There is a comparatively large vesicle studded internally with heads. The parasite produces prominent nervous symptoms, the disease called 'Gid,' 'Sturdy,' etc.

Literature.—Fully in LEUCKART, Paras. des Menschens, 2nd ed., 1879-1894 (first vol., transl. by Hoyle); NEUMANN, Parasites of Domestic Animals, transl. by Fleming, 1892; DAVAINE, Traité des Entozoaires, 1877; BLAND SUTTON (Intraperitoneal rupture of echinococcus), Brit. Med. Jour., 1892, i., 1184; BRAUN, Virch. Arch., xcii., 1883, and Zwischenwirth des breiten Bandwurmes, 1886; TARGETT (Hydatids in bone), Guy's Hosp. Rep., l., 1893. See also articles by MANSON, PEIPER and HUBER already mentioned.

IV.—NEMATODA OR ROUND-WORMS.

The round-worms have elongated bodies, and possess a well-developed digestive apparatus, with mouth, œsophagus, stomach, intestines, anus. The sexes are separate. Some of them bear living embryoes, while others produce eggs which become free, and afterwards develop embryoes.

1. **Trichina Spiralis.**—This worm is met with in the muscular tissue of man, and occurs there in immense numbers, producing the disease **Trichinosis.** We shall see afterwards that this is not the mature form of the worm, but it is in this form alone that, for the most part, it is accessible to us, and it will be convenient to begin with its description here.

The affected muscles, as seen with the naked eye, seem for the most part to be dusted throughout with fine white particles like sawdust. These are most abundant near the places where the muscular fibres are inserted into the tendons. As a rule the particles are most abundant in the muscles of the trunk, the diaphragm, the intercostal muscles, and those of the abdominal wall, but they may extend to all the voluntary muscles of the body, even the most distant ones of the hands and feet. It may be present in immense numbers, even in millions, in the same person.

On microscopic examination of the fine particles, they are found to consist each of an oval cyst with a tolerably thick wall (see Fig. 230, p. 408), within which is a small worm coiled up in a spiral manner. The cyst has very often abundant calcareous particles in its wall, especially at the poles, and, if the case is an old one, the impregnation with lime may be so great as to hide the parasite unless the salt be first dissolved out with an acid. When an acid, such as dilute hydrochloric, is used, the lime dissolves with some evolution of gas, and the whole structure becomes very transparent. Sometimes the worm dies in its capsule, and in that case the wall thickens and the cyst collapses to some extent on the remains of the worm, which itself often becomes infiltrated with lime (see lowest specimen in figure).

The parasite in man is derived from the pig, in whose muscles the embryoes occur in the same fashion as in man. The embryo worm is of small size, measuring, when uncoiled, about one twenty-fifth of an inch in length. If, now, a piece of muscle containing the embryoes in a living state—that is to say, not killed by cooking the meat—be eaten, they undergo further development **in the intestinal canal.** The capsule is dissolved by the gastric juice, and the embryo set free. It now grows rapidly, and in the course of two and a half days it reaches the **adult form,** when the female is about one-eighth of an inch in length, and the male slightly less. The male possesses a testicle consisting of a convoluted tube. The female has an ovary, vagina, and uterus. The adult worm has an intestinal canal from end to end, which is divisible into œsophagus, stomach, and intestine.

The impregnated ova pass into the uterus where they develop into living embryoes of minute size. In six or seven days after the female has attained sexual maturity, that is, eight or nine days after the trichinous muscle has been eaten, the birth of living embryoes begins. The female gives birth to large numbers, and probably continues to do so for some weeks, thus producing as many as 1000 to 1300. The adults do not live longer than five to eight weeks altogether.

The minute embryoes now begin to penetrate the intestinal canal, and they swarm outwards to the voluntary muscles. The route by which they reach the muscles is not absolutely certain. By most it is thought that they pass outwards into the peritoneal cavity, and thence into the connective tissue around, by which they travel to the muscles By others it is thought that they pass into the submucous connective tissue, thence into the connective tissue of the mesentery, and so onwards. It is probable that they find their way by both these routes, but it is inconceivable that, as some suppose, they get into the blood-vessels, as the vessels available are the portal radicles which would take them to the liver.

Swarming outwards from the intestine they reach first the muscles of the trunk, where they are usually most abundant; they then pass to those of the neck and larynx; and, lastly, to those of the limbs. Arrived at the muscles they grow larger, and apparently wander about for a time. They penetrate inside the sarcolemma of the primitive fibre of the muscle, and destroy the sarcous substance. In about fourteen days they have attained their full size, and begin to settle down. As they pass along inside the sarcolemma they are arrested at the insertion of the fibre into the tendon, hence they are particularly numerous near tendons, and here also the cysts, subsequently formed, are often much elongated. The sarcolemma collapses as the sarcous substance is destroyed, and as the worm coils itself up spirally the sarcolemma forms for it an oval cyst. The worm itself also adds to the cyst a layer of its own. It is not uncommon to find two, or even more worms, in one cyst. In the muscles the worms assume a quiescent state and may remain so for years (as long as eighteen years has been proved), the cyst being impregnated with lime. They produce considerable destruction by piercing the sarcolemma, and disintegrating the sarcous substance, and there is often to be found a germination of the muscle nuclei around the worm. The death of the host does not cause the death of the trichinæ. They will live in putrid flesh for weeks and remain capable of further development.

During the migration of the embryoes considerable irritation is produced. There is in the first week intestinal catarrh (diarrhœa), with fever, and the case may be mistaken for typhoid fever. Later, the muscles become stiff and painful, and œdema of the skin, especially of the face, may develop. This œdema of the face, which occurs about the seventh day, is said to be of special diagnostic significance. The symptoms are usually at their height in the fourth or fifth week, and death occasionally ensues. Cases of trichinosis may be readily overlooked post-mortem. This would have been the case in a recent example of this affection in a subject of phthisis had the writer not had occasion, before completing the autopsy, to examine the tongue microscopically. The presence of a single parasite in the substance of the tongue led to a more critical examination of the muscles generally, and the discovery of large numbers in almost every muscle examined. It has been shown recently that in acute cases of trichinosis an increase in the number of leucocytes is often present. This leucocytosis is characterized by an absolute and relative increase in the eosinophil cells. Its presence in doubtful cases may prove an aid to diagnosis.

Besides in man, trichinæ have been found in the muscles of the pig, cat, rat, mouse, marmot, polecat, fox, marten, badger, hedgehog, and racoon. By some it is believed that the rat forms the permanent source of infection, as, when one of these animals dies, it is eaten by its neighbours, and so the infection spreads. From their habits, it will be understood how swine sometimes partake of dead rats. The parasite may be communicated to man by eating imperfectly cooked swine's flesh. It is said that a temperature of 50°–55° C. (or 120°–130° F.), is enough to kill the embryoes, but it is quite conceivable that when large pieces of flesh are cooked rapidly, some parts may escape the thorough penetration of the heat.

The search for trichinæ in the muscles of swine before the flesh is sold is compulsory in some countries. For the examination pieces of muscle (preferably from the diaphragm and larynx) are snipped off with scissors and spread out in water on a microscopic slide. Some liquor potassæ may be added to make the preparation more transparent. It is then to be examined with low magnifying powers and afterwards with higher. Several specimens should be prepared from each animal.

2. **Ascaris lumbricoides.**—The common round-worm is probably the commonest entozoon in the human subject. It occurs very frequently in children, and inhabits chiefly the small intestine. In its colour and general appearance it resembles the common earth-worm (see Fig. 266). It measures 6 to 16 inches in length, is marked by transverse striæ, and tapers to both ends. Like other nematodes it possesses an intestinal canal from end to end. The female produces a large number of oval eggs which have a dense shell (see Fig. 267). The ova are discharged from the intestine and may be found in the fæces.

The worm mostly occurs singly or in pairs, but is frequently present in considerable numbers up to one or two hundred. From the intestine it may pass into the stomach and be vomited, or may be discharged per anum. It has been known also to pass up the œsophagus and into the nostrils and sinuses of the head, or by the larynx into the bronchial

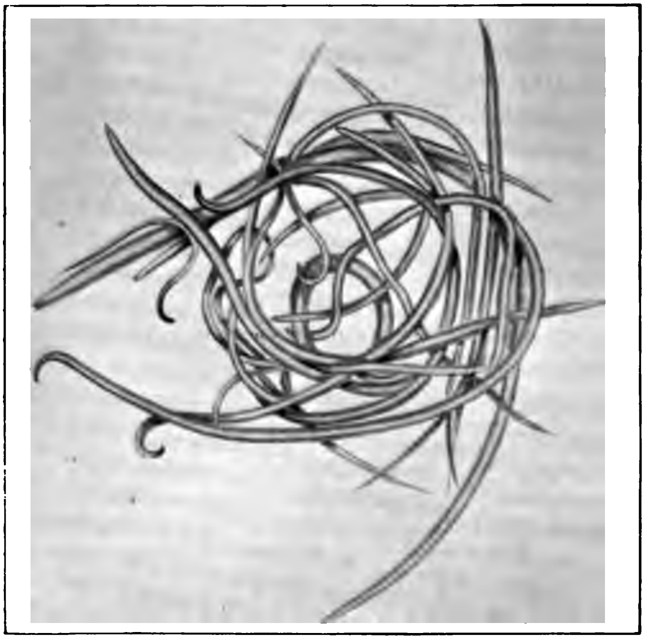


Fig. 266. - A clump of ascarides, large and small, from the intestine.

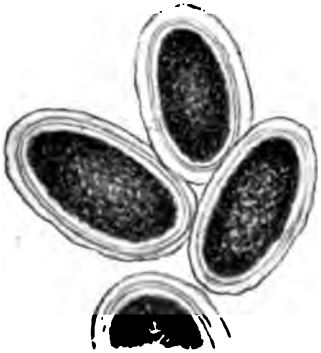


Fig. 267. Ova of ascaris lumbricoides. × 280.

tubes. Sometimes it penetrates into the bile ducts, which it may obstruct, or passes through the intestinal wall into the peritoneal cavity. In cases where they have perforated into the peritoneum they have given rise usually to local abscesses pointing chiefly near the umbilicus or groin. More rarely they have led to general peritonitis.

In the intestine the irritation of the worms produces catarrh, and by reflex action this is supposed to lead to certain nervous symptoms. When present in large numbers, the worms are sometimes rolled up in a ball, and in this condition they may obstruct the intestine.

Ascaris mystax.—This is a small round-worm which occurs in the cat, and is said to be always present in the intestine of that animal.

Oxyuris vermicularis or Thread-worm.—This is an exceedingly common parasite. It is white in colour, and the male measures about an eighth of an inch, and the female about three-eighths in length. It possesses an alimentary canal from end to end. The eggs are oval, and have a dense shell. The animal inhabits mostly the large intestine. It is stated by Zenker and Heller that the mature female is in the large intestine, the males and young being in the small. The worm often wanders, especially during the night, to the neighbourhood of the anus, where it produces itching. Sometimes it passes over to the vagina, and up into it. It produces catarrh of the bowel, and, as in the case of the ascaris, nervous symptoms are ascribed to it.

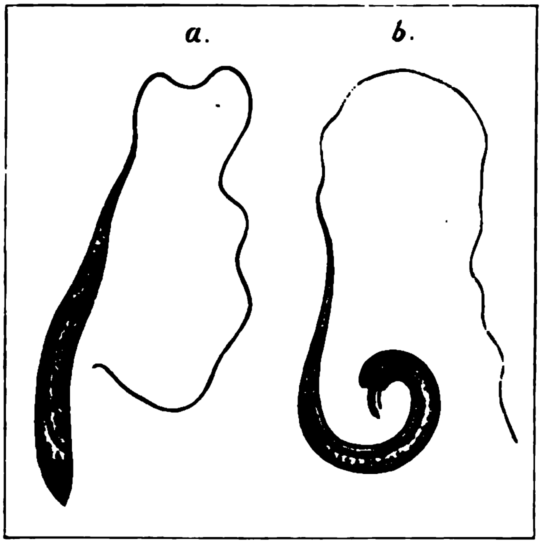


Fig. 298.—Trichocephalus dispar or whip-shaped worm from the cæcum. a, female; b. male. × 3.

Trichocephalus dispar (the whip-shaped worm).—It is of frequent occurrence in the cæcum and neighbouring parts of the intestine. It measures $1\frac{1}{2}$ to 2 inches in length and has the peculiarity that the anterior portion is much thinner than the posterior, forming a long thread, like the lash of a whip (see Fig. 268), which is buried in the mucous membrane. It seems to produce no special symptoms. The eggs possess a brown shell. The embryoes have been traced in water and moist earth.

Ankylostomum duodenale (*Dochmius duodenalis, Strongylus Duodenalis*).—This worm is rarely met with in this country, but occurs in Egypt, Italy, and tropical lands. It has been found frequently among the workers at the St. Gothard Tunnel in Switzerland, and has been met with in workers in certain mines and brick-works. Its habitat is the small intestine, especially the lower part of the duodenum and the jejunum where it may be found amongst the valvulæ conniventes in large numbers—it may be in hundreds or even in thousands. The male ankylostomum is a very small intestinal worm, measuring usually less than half inch in length. The female is slightly larger (see Fig. 269). When alive they appear whitish-grey, or, when full of blood, reddish-brown. The mouth of the parasite is armed with four strong claw-like hooklets, and two conical teeth. By means of these it fixes itself to the mucous membrane of the intestine so firmly that it is with difficulty removed. Then, buried in the mucous membrane, it drains the blood of its host. It is credited with changing the place of its attachment

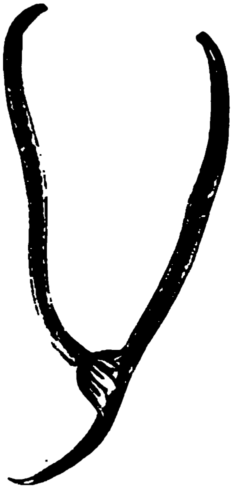


Fig. 269.—Ankylostomum duodenale, male and female. × 3.

from time to time, leaving behind it points from which blood may ooze. Very considerable loss of blood may thus arise, and serious anæmia. The female produces an enormous number of eggs which may be recognized microscopically in the stools as transparent, smooth, oval bodies, with a greyish, segmented yolk. Once outside of the human body these rapidly develop under favourable circumstances into active embryoes which equally rapidly increase in size, and after two successive moultings, pass into a larval state in which they may live for weeks or months. The larval stage is usually passed in muddy water, mud, or moist earth. Infection in the human subject probably occurs from earth containing larvæ being carried to the mouth, either on the hands or with the food, and possibly, also, from the drinking of muddy water. Infection through the hair follicles of the skin has been asserted. Once in the alimentary canal the larvæ soon acquire sexual characters and develop into adult worms; these evidently may live for years.

Ankylostomiasis is the name given to a group of symptoms induced by the presence of the parasite in large numbers in the intestine. The most obvious of these is **Anæmia** (*Anæmia Egyptorum*), which may be very severe. This is due to the direct loss of blood, but probably contributing causes are the elaboration of some toxic substance by the parasites or the absorption of intestinal toxins through the intestinal lesions. Gastro-intestinal disturbance and cardiac weakness are frequent concomitants.

Strongylus gigas.—This is a large worm, reaching a length of over a yard, and a thickness of about three-eighths of an inch. It has been met with a few times in the pelvis of the kidney in man, and more frequently in the kidney, bladder, lungs, and liver of dogs.

Round-worms belonging to the family of the **Strongylidæ** are frequent parasites **in the lower animals**. These inhabit various parts of the body, but there are two situations in which they are of special frequency, namely the lungs and the arteries.

Pulmonary and bronchial Strongylosis is the name applied to the conditions produced by various strongyli when resident in the bronchial tubes and lung-parenchyma. No less than eight species of the genus strongylus have been distinguished (Neumann), and the animals affected include the sheep, goat, deer, pig, ox. horse, ass, hare, rabbit, and cat. The disease is seen in its most characteristic form **in the sheep**. There are two species met with in this animal, namely, the **Strongylus filaria** which inhabits the bronchi and gives rise to bronchitis and the **Strongylus rufescens** which penetrates to the lung alveoli. In the latter case a pneumonia is produced, each worm being the centre of a local inflammation. There are thus nodules which have a superficial resemblance to tubercles (see Fig. 270). In Fig. 271 large numbers of strongyli are seen completely occluding the bronchial tubes.

Aneurysms are frequent in **the horse** and **ass** in consequence of the action of one of the Strongylidæ, the *Sclerostoma armatum* or *equinum*. The worm is first present in the large intestine, from which it penetrates to the arteries which come off from the abdominal aorta, chiefly the cœliac and mesenteric arteries, very rarely the aorta itself. The worm produces thrombosis and aneurysmal dilatation of the vessels. From the discharge of portions of thrombi, embolism in the arteries of the intestine results, giving rise to colic, which is a frequent symptom in the horse. The aneurysms are present in about 90 per cent. of horses, and are equally frequent in asses.

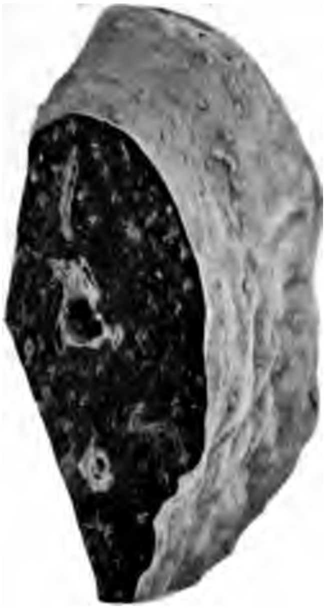


Fig. 270.—Strongylosis. Lung of sheep

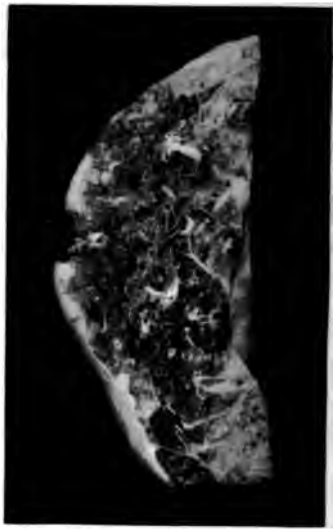


Fig. 271.—Strongyli occluding the bronchial tubes. From the lung of a pig.

Filaria medinensis (*Dracunculus medinensis* or *Guinea-worm*).—This parasite is of frequent occurrence in tropical lands, where it is met with in the tissues of the foot and leg chiefly. The female is a long thin worm from 12 to 40 inches in length, and it alone is known as a parasite. The worm wanders to some extent in the loose subcutaneous connective tissue, and may give rise to considerable irritation. When mature it presents its extremity at the surface, and a small pustule forms from which the extremity projects. The worm may then be removed gradually by rolling it gently round a quill from day to day as it becomes exposed, care being taken not to break it, in which case the part left in may give rise to severe inflammation.

Filaria sanguinis hominis. Filaria Bancrofti. Filaria nocturna.—This parasite is best known in the embryonic form which inhabits the blood. The adult form rarely comes under observation, but has been found occasionally in the lymphatic system. It has been named **Filaria Bancrofti** from the first discoverer of the adult.

The adult filaria is a hair-like worm 8 to 10 cm. (3 or 4 inches) in length, and only about 0·35 mm. ($\frac{1}{100}$ of an inch) in breadth. It sometimes produces considerable irritation in the lymphatics, causing local thickenings. Maitland has excised some of these thickenings and found in one case as many as seven adults in one mass. The adults are believed to live for years in the lymphatics, and the female gives birth to enormous numbers of living embryoes which find their way into the blood.

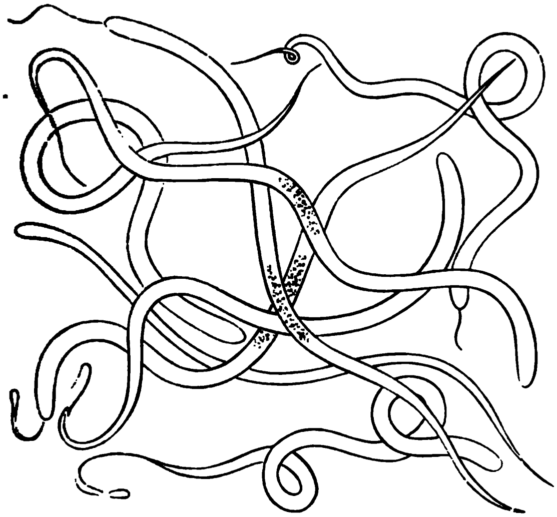


Fig. 272.—Filaria sanguinis as they appear in the living state in the blood. From a case of chyluria. × 300. (Lewis.)

The living embryo (Fig. 272) is about $\frac{1}{90}$ inch in length and $\frac{1}{3500}$ inch in thickness; its breadth therefore nearly corresponds with that of a red blood-corpuscle. It is enclosed in a delicate sac, which is rather longer than itself, so that while moving a portion of the sac extends beyond its extremity. The movements as seen in the blood and lymph are very active and snake-like in character.

This embryo is present in the blood of about 10 per cent. of the natives where it is endemic, and most of these do not appear to suffer in health from it. It is found in many Eastern countries and in Brazil, the West Indies, etc. A very remarkable circumstance is that, during the day, the parasites are, unless in exceptional cases, absent from the blood obtained from the finger or other superficial part, but about six or seven o'clock in the evening they begin to appear, and by twelve o'clock are so numerous that as many as a hundred may be counted in every drop of blood. As morning approaches they diminish in numbers, and by eight or nine o'clock they disappear entirely. This regular rhythm may apparently go on for years. When the periodicity of the bodily functions is interfered with by the person sleeping during the day and doing his work at night, then the parasite is present in the blood in the daytime and absent at night.

The periodicity has been variously accounted for. It is either that the animals come to the superficial vessels during the night and remain in the internal organs during the day, or that a fresh brood is produced every evening. As the number in the blood of a single person is estimated at 36-40 millions (Mackenzie) the latter supposition does not seem probable.

According to Manson there are several species of filaria sanguinis, in addition to the F. Bancrofti. These may be distinguished by structural and other differences in the embryoes and by the presence or absence of periodicity in their appearance in and disappearance from the blood. Thus *F. diurna* is met with during the day and disappears at night. *F. perstans* and *F. Demarquaii* are constantly present both by day and night.

Chyluria, chylous diarrhœa, lymph-scrotum, and **elephantiasis** have been ascribed to the filaria Bancrofti. The embryoes in passing from their parents in the lymphatics to the blood have to traverse the lymphatic glands. In certain cases they seem to stick in the glands, and by filling them up obstruct the passage of lymph. There may thus be virtually a plugging of the lymphatics with a dilatation of the distal parts of the vessels. Rupture of the vessels causes the escape of the chylous contents (see p. 102). According to the situation of the adults the results vary. The rupture may be in the urinary bladder or kidneys, and we then have **chyluria.** There is usually **blood** also in the urine from tearing of blood-vessels, and, for a similar reason, the embryoes may be present in the urine. In a similar manner **chylous diarrhœa** is produced. **Lymph-scrotum** is a thickening of the scrotum with the presence of dilated lymphatics and vesicles which rupture and discharge fluid. **Elephantiasis** is not probably a direct effect of the parasite, but the condition of lymph-scrotum may give occasion to elephantiasis (see pp. 210, 211).

The **mosquito** is believed by Manson to be the intermediate host of the filaria, but this view seems to stand in need of confirmation.

In animals many forms of filaria exist. There are several forms in the dog. One of these inhabits the trachea and bronchi, producing bronchitis. It has been named *Filaria Osleri*, from Prof. Osler who observed it in Canada and regarded it as a strongylus. The *filaria immitis* inhabits the right cavities of the heart and the pulmonary artery of the dog, and is very common in China and Japan. The adults, which measure 12 to 30 cm. in length, give off embryoes closely resembling the filaria sanguinis hominis, and like it appearing in the peripheral vessels at night. The *Spiroptera sanguinolenta* (so called from its red colour) is found chiefly in the walls of the stomach and œsophagus of the dog in China and Brasil. It forms considerable cysts, in the interior of which the worms, which measure 3 to 5 cm., are found coiled up together. It also occurs in the walls of the aorta, in the lungs, and in lymphatic glands.

In the horse a frequent parasite is the *Filaria papillosa* which inhabits the serous membranes, as the peritoneum and pleura. In may be present in enormous numbers in these cavities. It has been found in the tunica vaginalis when a horse was being castrated, having descended from the peritoneum. It measures from 6 to 15 cm. in length.

Literature.—Virchow, Die Lehre von den Trichinen, 1866; Ritchie, Encyclop. Medica, ix., 1901; Sutherland, Glas. Med. Journ., xlviii., 1897; Brown (Blood in Trichinosis), Johns Hopkins Hosp. Bull., iii., 1897, and Journal of Exp. Med., iii., 1898; Da Costa, Clinical Hæmatology, 1902; Lewis, Path. significance of nematode hæmatozoa, 1877; Bancroft, Path. Trans., 1878, xxix.; Manson, Filaria sang. hom., 1883, also Path. Trans., 1881, xxxii.; Mackenzie, Path. Trans., 1882, xxxiii., 394; Myers, Observations on Filaria sang. hom., Shanghai, 1881 and 1886; Scheube, in Volkmann's Sammlung, 1883, No. 232; Neumann, transl. by Fleming, 1892; Maitland and Manson, Brit. Med. Jour., 1894, l., 844; Manson, Allbutt's Syst. of Med., ii., 1897; Huber, 20th Cent. Pract. of Med., vii., 1897; Rogers, Journ. of Path. and Bact., v., 1898.

V.—EPIZOA OR EXTERNAL PARASITES.

These do not call for extended treatment here, as they are fully described in works on diseases of the skin. Little more than an enumeration of them will be attempted.

1. **Arachnida.**—Parasites belonging to this class occur both in man and animals. In one form the larva inhabits the internal parts, while the adult is external.

Acarus scabiei, or Sarcoptes hominis.—This has an oval body just large enough to be visible to the naked eye, the female being one fiftieth of an inch in length, and the male about half that size. The anterior part has a head and four limbs, each of which has a sucker at its extremity. There are also four posterior limbs, all of which in the females have pointed extremities, but in the male two of them have suckers. The female burrows in the epidermis, forming tunnels, in which, as it proceeds, it deposits its eggs; it is usually to be found at the deepest end of the tunnel and the eggs at intervals. The eggs develop, and, as the epidermis desquamates, they come to the surface by degrees, the young being born usually as they reach the surface. The irritation of the animal in the epidermis gives rise to a slight inflammation, causing the formation of a papule. Usually there is a great itching, and the scratching leads to further eruptions, especially in predisposed persons.

Acarus folliculorum (Demodex folliculorum).—This is an elongated animal about $\frac{1}{125}$ of an inch in length, and provided anteriorly with four pairs of short feet. It is found in the sebaceous follicles, especially of the external meatus of the ear and neighbourhood of the nose. It seems to produce no special irritation in the human subject; in animals, especially dogs, it gives rise to extensive cutaneous lesions (*Follicular mange*).

Pentastoma denticulatum s. tænioides.—The larval form is very common in the rabbit, and has been not infrequently observed in man. It occurs usually in the liver, but has been observed also in the spleen, lungs, kidneys, and wall of intestine. It is a small animal about a fifth of an inch in length and a fifteenth in breadth. It presents about 90 segments, in each of which are stomata. The mouth possesses four hooks which can be withdrawn into chitinous sheaths. The larva in the liver surrounds itself with a capsule and forms a nodule about the size of a pea. In man they are mostly found dead, and the condition observed is that of a hard nodule surrounded by a fibrous capsule, inside which are the calcified remains of the animal, of which only the hooks may be recognizable.

The larva found in the liver and elsewhere is usually designated the Pentastoma denticulatum, while the adult is called the P. tænioides. The connection between the two was demonstrated by Leuckart. The adult is found chiefly in the nares of dogs, and also of some other animals, and on one occasion of man (Laudon). The adult is like the larva in form but much larger, the female measuring three inches, and the male about one. The mouth is devoid of hooks. The ova passing from the nostrils of the dog on to the grass are supposed to be taken into the stomachs of hares and rabbits, and to pass thence to the liver.

Many forms of arachnida occur in animals.

Leptus autumnalis (Harvest bug).—This is a small red animal, just visible to the naked eye. It is not a necessary parasite, but in some districts it invades the legs and burrows into the skin, thus causing excessive itching. Two other forms of leptus are described as occurring in America (Duhring).

2. **Insecta or Insects.**—The parasitic insects occur entirely externally. Some of them are not parasitic at all times.

Pediculi or Lice.—The head louse (P. capitis) lives among the hairs. It forms a chitinous sheath for its ova, which it cements to the hairs. The young, when they emerge from the egg, are like the adult in form, there being no further metamorphosis. The body louse (P. vestimentorum) is like the former but considerably larger. The ova are deposited in the clothing, especially the seams, where also the adults congregate. The crab louse (P. pubis) has its popular name from the fact that it has long curved claws with which it attaches itself to the hairs. It occurs in the parts of the body furnished with stiff hairs, chiefly the pubes, but also the axillæ, eyebrows, beard, eyelashes, etc. It is smaller and less elongated than the other two forms.

Pulex irritans (Common flea).—This animal is only partly parasitic. Its larvæ, which are about an eighth of an inch in length, occur in quantities in the neighbourhood of mouldering organic matter, in dusty corners of rooms, etc.

Cimex lectularius (Common bug) is still less of a parasite. It lives chiefly about beds, and comes out of retired parts on to the skin to extract blood.

Pulex penetrans (Sandflea, chigoe, jigger).—This is common in the West Indies, Central and South America, and southern parts of North America. The female, which resembles an ordinary flea, penetrates the skin, usually of the toes, where it swells up into a sac about the size of a pea, the abdomen being distended with ova. It produces painful inflammation.

The Larvæ of insects or Maggots are occasionally found in the tissues of man. There are a few cases in which such larvæ have, by migrating under the skin, produced considerable inflammation. There are also cases in which, deposited in neglected wounds, or even in the mouth and nostrils of excessively debilitated persons, they have actually produced considerable destruction by feeding on the tissues. In neglected military hospitals wounds are often abundantly tenanted by maggots.

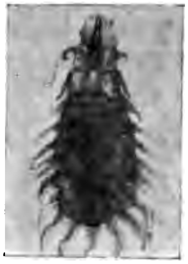


Fig. 273.—Larva of anthomyia canicularis. Many such larvæ were passed by the intestine. × 8.

The Larvæ of insects are also sometimes **passed by the bowel.** The form which has been chiefly observed is the **Anthomyia canicularis.** In some cases enormous numbers of the larvæ of this fly (see Fig. 273) have been passed, stated as quarts in one report. (See Finlayson, in *Glas. Med. Journ.*, xxxiv., 225, 1889.)

PART SECOND—DISEASES OF THE SPECIAL ORGANS AND SYSTEMS.

SECTION I.

ALTERATIONS OF THE BLOOD AND ITS CONSTITUENTS.

Constituents of the blood:—(1) Plasma; (2) Erythrocytes; (3) **Leucocytes**; Blood-Plates, Hæmoconia. I. **General hyperæmia**, Plethora; **produced** artificially by **Transfusion of blood**; Plethora as a pathological condition. II. **General anæmia**: (1) **Causation**: (*a*) From destruction of red corpuscles, hæmorrhage, hæmoglobinuria; (*b*) From defective formation. (2) **Character of the changes in the blood** in oligæmia; in pernicious anæmia; in chlorosis; in secondary anæmias. (3) **The bone-marrow in anæmias.** (4) **Secondary changes in anæmias.** III. **Leucocytosis.** IV. **Leukæmia**, Causation obscure. changes in blood and nature of the disease; condition of bone-marrow: spleen; lymphatic glands; liver, kidneys, etc.

THE blood may be regarded as a tissue which is being continually changed by loss and renewal of its constituents. It is a fluid in which are suspended red and white cells or corpuscles, and it is a vehicle by which the nutritious material required by the tissues, and the oxygen necessary for their respiratory processes are conveyed; the former function being performed by the liquor sanguinis, and the latter by the red corpuscles. It also carries off to their proper places of excretion the products of tissue change, and the carbonic acid resulting from the respiratory process in the tissues.

Constituents of the blood.—The blood is composed of a fluid part, the blood-plasma, and of solid elements, the blood-corpuscles. The latter constitute two-fifths of the total volume. The total amount of blood in the normal adult is usually stated as about $\frac{1}{13}$ of the body weight. Estimated by the method recently brought forward by Haldane and Lorrain Smith, the proportion is considerably less.

1. The **blood-plasma** holds in solution two albuminous substances, namely, serum albumen and fibrinoplastin or serum globulin, besides

a variety of nitrogenous substances in small quantity, most of which are in process of excretion, such as urea, uric acid, kreatin, etc. There are besides, as constant constituents, fats, sugar, and various salts, of which the chief are sodium chloride and phosphate.

2. The **Erythrocytes** or **red corpuscles** are disc-shaped bodies, measuring 7·5 μ[1] in average diameter. Their chief constituent is hæmoglobin. The origin of these corpuscles cannot yet be said to have been unequivocally determined. In the early embryo they are formed coincidently with the blood-vessels, and the cells that develop into the latter give origin to the red corpuscles, which are thus intracellular products. This method of production, however, ceases before birth, and in the embryo itself, and in the individual throughout extra-uterine life, a different mode of origin must be looked for. The bone-marrow is agreed upon by most authors as the chief permanent seat of origin of the red corpuscles. In the red marrow of the cancellous tissue of bones, and more particularly of the ribs, the venous sinuses present special nucleated cells (erythroblasts) which give origin to red corpuscles. Whilst the bone marrow is the chief source, the spleen and other lymphatic structures also probably take part. There is no evidence to support the view that they arise by transformation of leucocytes in the circulating blood, and Hayem's theory that they are developed from hæmatoblasts has few adherents (see later).

A great destruction of red corpuscles is continuously taking place, as the bilirubin in the bile is entirely derived from the hæmoglobin of the corpuscles. The destruction of the corpuscles does not occur in the general circulation, but most probably takes place in the spleen. This great and constant loss of corpuscles implies an equal new-formation and replenishment. In pathological conditions, especially in anæmias, striking divergencies from the normal may be observed in the red blood corpuscles. Thus the diameter may be increased (*megalocyte*, *macrocyte*) or diminished (*microcyte*). Marked alterations in the outline of the corpuscle may occur (*poikilocyte*), and obvious loss of colour is sometimes observed.

3. **The Leucocytes.**—This term may be applied to free colourless corpuscles whether present in the blood (hæmic) or in the lymph, serous spaces and lymphatics. There are several readily distinguishable forms of leucocytes, and they are found to differ among themselves according to the characters of the nucleus and protoplasm. As to the nucleus, the form and relative size are important characteristics, and as to the

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[1] The Greek letter μ is used to represent a micromillimetre or mikron, *i.e.* $\frac{1}{1000}$th of a millimetre.

protoplasm, the presence or absence of granules and the characters of these granules are determining points of distinction.

Before describing the various forms, the character of the granules may be mentioned. Many leucocytes present in their protoplasm numerous granules, in some cases large, in others small. The ingenious observations of Ehrlich have shown that these granules differ in their reactions to alkaline and acid staining agents, these differences indicating differences in the vital chemistry and function of the various kinds of cells. The aniline dyes are divisible into the basic and the acid forms. The former include the regular dyes for nuclei and microbes, such as methylene-blue and fuchsine. The latter are not nuclear stains, and the most familiar are eosin, acid fuchsine, aurantia, and orange G. Ehrlich has divided the granules into three, according as they stain with acid, alkaline, or mixed dyes, naming them respectively **Eosinophil**, **Basophil**, and **Neutrophil** granules. Alterations in this nomenclature have been made, the term **Oxyphil** or **Acidophil** replacing eosinophil, and neutrophil being given up by most observers on the ground that the mixtures of basic and acid dyes (such as Ehrlich's triple stain) act as acid stains. The various forms of leucocytes are sometimes named according to the character of the nucleus and sometimes according to that of the granules, so that two or more names may be applied to the same kind of cell.

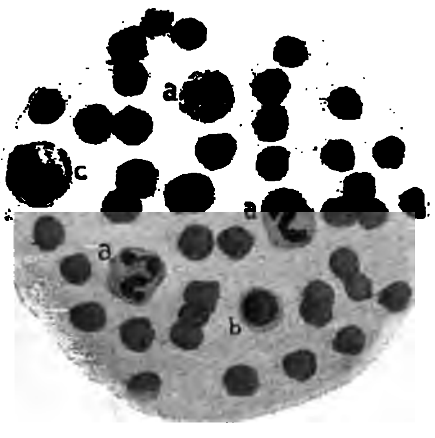
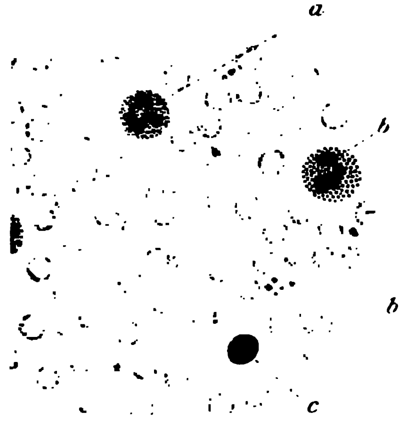


Fig. 274. Blood corpuscles, stained with hæmatoxylin and eosin. Many red corpuscles are seen and three of the commoner forms of leucocytes: *a*, polymorphonuclear leucocyte; *b*, small lymphocyte; *c*, large uninucleated leucocyte with deeply indented nucleus.

It is to be remembered also that all these cells, whether hæmic or not, are free, that most are amœboid, and that, like other amœboid bodies, some of the forms have the faculty of picking up solid granular matter, in other words of playing the part of phagocytes.

Taking first those of the blood, the following are the forms of leucocytes most commonly met with. 1. The **Polymorphonuclear** (neutrophil, or finely granular oxyphil) **Leucocyte** is much the most frequent form comprising from 70 to 75 per cent. of the white blood corpuscles (Figs. 1 and 2, Pl. I.). The corpuscle

PLATE I.



-Normal Blood. × 600.
an's modification of Ramanowsky's stain.
morphonuclear leucocyte. *b.* Eosinophil leu-
c. Lymphocyte. *d.* Erythrocyte. *e.* Blood

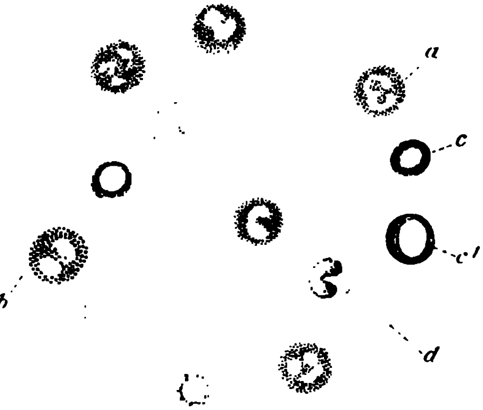
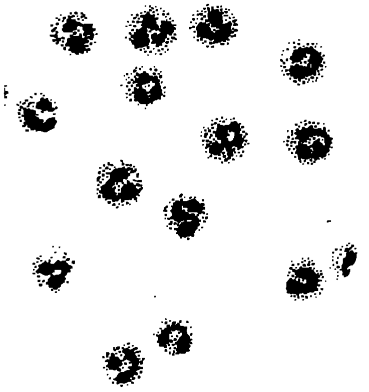


Fig. 2.—Various forms of Leucocytes. Normal blood, × 600.
Ehrlich's triacid stain. *a.* Polymorphonuclear leucocyte. *b.* Eosinophil leucocyte. *c.* Small lymphocyte. *c*¹. Larger lymphocyte. *d.* Erythrocyte.



Leucocytosis in Septicæmia. × 600.
lin vapour preparation. Eosin and methylene
ain. Increase of polymorphonuclear leucocytes.

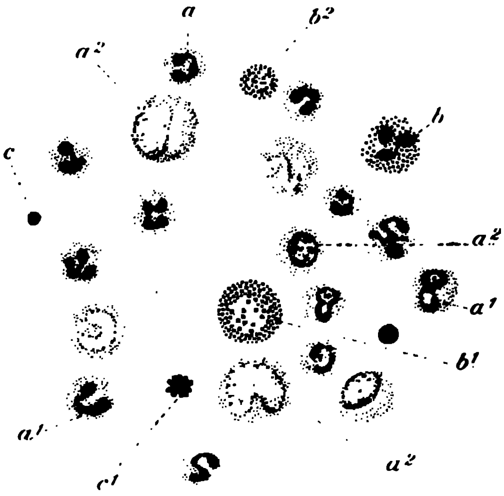


Fig. 4.—Blood in Myelogenous Leukæmia. × 600.
Formalin vapour preparation. Eosinated hæmatoxylin and methylene blue stain. *a.* Fully formed polymorphonuclear leucocyte. *a*¹. Transition form. *a*². *Myelocyte.* *b.* Fully formed eosinophil leucocyte. *b*¹. Eosinophil myelocyte. *b*². Small eosinophil leucocyte. *c.* Normal erythroblast. *c*¹. Erythroblast in mitosis.

LONGMANS, GREEN & Co., London, New York, and Bombay.

usually from 10 to 12 μ, but they are variable in size. re met with not much larger than small lymphocytes. Other ay be nearly twice their size. It has a nucleus which is so roken up into lobes that it looks as if there were several uclei (hence often called *multi-nucleated Leucocyte*), but, on examination, a fine thread of chromatin is usually found he lobes. The nucleus stains dark-blue or greenish-blue with triple stain, and intensely blue with eosin and methylene- xtures. The protoplasm is full of very fine granules—so- utrophil granules—which stain purple or reddish purple with triple stain. As a rule, they remain unstained in films with eosin and methylene-blue. As has been mentioned, these are not strictly neutrophil, but possess a feeble affinity for s. The polymorphonuclear leucocytes are actively amœboid gocytic—constituting the microphags of Metchnikoff.

e **Small Uninucleated Leucocyte** (*Lymphocyte, Small Lym-* is a small cell—the smallest of all the leucocytes—being bout the size of a red blood-corpuscle, 7·5 μ (see Figs. 1 and 2, It has a single rounded nucleus which almost monopolizes the ll, leaving a very narrow rim of protoplasm. The nucleus stains faintly blue with Ehrlich's triacid stain. If a blue counter-stain yed after the use of the triple stain an intense blue colour may ined. The protoplasm is stained a greyish colour or faintly pink. With eosin and methyl-blue the nucleus is usually blue, the protoplasm often staining a purplish tint. Diver- in the shape of the nucleus and in the staining reactions ally are seen. The lymphocyte forms 10 to 20 per cent. of ic leucocytes, and is abundant in all lymphoid tissue. It is amœboid nor phagocytic.

hocytes, considerably larger than those above mentioned, are nmonly met with in the blood. They are probably inter- forms—or stages of development between the large and small ated leucocytes.

e **Large Uninucleated Leucocyte** (*Large Lymphocyte, Large Cell*) is the largest of all the leucocytes of the blood, ng on an average about 11 μ in diameter. The outline of the be circular, ovoid, or markedly irregular. The protoplasm, relatively much larger in amount than is the case in the small ytes, is free from granules. The nucleus is rounded, oval, or l, giving sometimes a reniform outline (Fig. 2, Pl. I.). The lear network is diffuse. Both protoplasm and nucleus stain with the dyes commonly used. Large uninucleated leucocytes, with nuclei approaching in their form the nuclei of the polymorphonuclear leucocytes, are not infrequent. They are sometimes grouped separately as *transitional forms*, but are more conveniently included along with the large lymphocytes when the number of the different forms of leucocytes present in the blood is being estimated.

The large lymphocytes, including the forms just mentioned, form rather less than 10 per cent. of the white blood-corpuscles. They are both amœboid and phagocytic.

4. The **Eosinophil** (*coarsely granular oxyphil*) **Leucocyte** is present in small numbers in the blood, usually about 2 per cent. The size varies greatly, the average being about the size of the polymorphonuclear leucocytes. The nucleus is polymorphous, reniform, horse-shoe shaped, or lobed (Fig. 2, Pl. I.). It is usually eccentric. It stains pale blue or greenish blue with Ehrlich's triple stain, and dark blue with eosin and methylene-blue mixtures. The protoplasm is full of large spherical granules which stain deeply with the acid elements in Ehrlich's triple stain and with the eosin in mixtures of eosin and methylene-blue. When present in a blood film they are the most conspicuous of all the leucocytes. The cells are evidently delicate structures and are often injured in the preparation of the film. The cell has the appearance as if it had exploded and scattered its granules irregularly around the free nucleus. Eosinophil cells are amœboid, but are not phagocytic.

The **Basophil Leucocyte** is a form only very occasionally met with in normal blood. It is found in cases of myelogenic leukæmia. It resembles the polymorphonuclear leucocyte in general form and size, but its staining reactions are different. The nucleus is coloured dull blue with Ehrlich's triple stain, and pale green with eosin and methylene-blue mixtures. The protoplasm contains fine granules which have a basic reaction. The granules stain deep blue with methylene-blue solutions, but are unstained by Ehrlich's triple stains. The **Mast-zellen** of Ehrlich, frequently met with in the tissues, give similar staining reactions.

Myelocytes are large uninucleated cells with neutrophil or oxyphil granules. They do not occur in normal blood, although found in large numbers in red marrow. They are often strikingly abundant in the blood in cases of myelogenic leukæmia, and have been seen in small numbers in several forms of anæmia and in certain chronic cachectic conditions (see Leukæmia).

With regard to the origin and development of the different forms of leucocytes, opinions differ. According to Ehrlich, the large and small lymphocytes are developed in lymphatic tissue in various parts of the body. The large uninucleated leucocytes and transitional forms are regarded as originating in the bone marrow. Polymorphonuclear leucocytes are also derived from the bone marrow—the great majority from neutrophilic myelocytes—a very small minority, probably, from the large uninucleated cells. Eosinophil and basophil leucocytes both originate in the bone marrow—the former from eosinophil-myelocytes. Thus, according to Ehrlich, all the leucocytes originate in bone marrow with the exception of the large and small lymphocytes, which are developed in lymphatic tissues. Only in rare instances do the leucocytes multiply in the blood stream.

Blood-plates. Bizzozero's third corpuscle.—Hayem and Bizzozero have alleged the presence of a third form of corpuscle in the blood. Hayem gives the name hæmatoblast, and Bizzozero that of Blutplättchen to this corpuscle. Hayem's name implies the view that these form the red corpuscles, and as this view is incorrect the name is inadmissible. We shall refer to them under the designation blood-plates (see Fig. 1, Pl. I.). They are small colourless bodies, oval or circular in outline and disc-shaped. In cold-blooded animals there are spindle-shaped bodies which are regarded as of a similar nature. The blood-plates undergo rapid changes when once removed from the body, running together into indefinite granular masses. They may be prevented from changing if the blood be rapidly dried on a cover-glass and stained with methyl-violet (Schimmelbusch). The existence of these bodies as independent formed corpuscles is exceedingly doubtful, and their appearance is probably to be accounted for by the fact that various interferences with the blood, and especially cooling, causes a rapid deposition of solid granules having the forms described by Bizzozero. They are variously regarded as portions of globular matter extended from the red blood-corpuscle, as fragments of disintegrated nuclei of leucocytes, or as masses of precipitated globulin. The average number present in one cubic millimetre of blood is 300,000. The number may be increased, as in anæmia, leukæmia, and other diseases, or diminished, as in purpura, hæmophilia, erysipelas, malaria, etc.

Hæmoconia (blood dust) is the name given to the minute colourless refractive bodies met with in blood, and resembling in appearance fine fat granules or micrococci. Their nature and significance are unknown.

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I.—GENERAL HYPERÆMIA. PLETHORA.

These terms designate a condition in which the total quantity of blood in the body is in excess. The number of red corpuscles is generally set down as normally about 5 millions per cubic millimetre in men, and 4·5 millions in women. The number of the white corpuscles is much more variable, increasing, for example, after a meal, but it may be set down as 6000 to 10,000 per cubic millimetre (see Leucocytosis). The first question that arises here is, whether the vascular system is capable of accommodating more blood than it contains normally. There is no difficulty in answering this question in the affirmative. If the vessels as a whole could contain no more blood than they normally hold, then there could be no local variations, no blushing, no increase in the quantity of blood during activity of organs. The capillaries and minute arterioles present great variations in the amount of blood they contain at different times, and if we take the whole capillaries of the body into account, it is evident that in them there is a great reserve space which may possibly on occasion be used for the accommodation of an excess of blood. This matter has been brought to the test of experiment, blood having been transfused into the circulatory system in animals.

Transfusion of blood is the artificial introduction, into the vascular system, of blood from another person or animal.

In the experiments of Worm Müller, which are chiefly of importance here, the defibrinated blood of dogs was injected, with precautions, into the vessels of animals of the same kind. It is not remarkable that the vascular system can accommodate a large additional quantity of blood, but it is remarkable that it should do so with so little disturbance to the health of the animal. A quantity equal to a half or three fourths of the blood normally present in the animal may be injected without injuring the health of the animal, and the quantity needs to be double the normal, or over it, before the animal's health is seriously impaired. It might be expected that when the vascular system is thus overfilled the blood-pressure would be greatly raised, but registration of the pressure, by a cannula introduced into the carotid and connected with a kymographion, shows that though during the actual operation there is a rise of pressure, yet it soon falls to within normal limits. If a quantity is injected more than equal to the normal bulk of the blood, then the pressure begins to show remarkable elevations and depressions, and the animal usually dies in the course of the same day or the next. Life is immediately endangered when one and a half times the normal bulk is injected.

When blood is transfused then in large quantity it finds accommodation chiefly in the capillaries and veins, the arteries being relaxed in order to admit of its passing into these, and the blood pressure is not raised. It appears that the capillaries and veins of the abdominal organs form a great reservoir for the accommodation of excessive blood, and that the blood after transfusion lodges here chiefly.

The excess of blood thus supplied to an animal does not, however, remain permanently as part of its organism. There seem to be arrangements in the body for disposing of it. Worm Müller endeavoured to determine what time it took to dispose of a large excess of blood. After the transfusion the animals were starved, and the blood and urine examined at intervals. It was concluded that the fluid of the blood is rapidly disposed of, being excreted by the urine. A few hours after transfusion much of the excess of liquor sanguinis had already gone, and even when a quantity equal to 60 to 80 per cent. of the entire blood was injected, the whole excess had disappeared in the course of two or three days. The rapid disposal of the liquor sanguinis leaves the blood-corpuscles greatly in excess, and the rate of disappearance was determined by counting them by means of Malassez' method. If the quantity transfused is small, the corpuscles may be disposed of in a few days; but in the case of large transfusions it may take two or even three weeks. In this comparatively short period of time, however, the whole excess of blood, both plasma and corpuscles, is removed, and we may infer that there are arrangements in the body for the regulation of the amount of blood.

These experiments all refer to the transfusion of defibrinated blood. If blood is injected when just **about to coagulate**, or if when it has just begun to coagulate, some of the serum is pressed out and injected, then in some cases the animal dies rapidly with symptoms referable to pulmonary embolism.' The blood in the right side of the heart and pulmonary artery is found after death to be coagulated. The explanation of this is that, at the time of coagulation of the blood, the substances resident in the leucocytes necessary to coagulation are set free. It appears that even a small quantity of these substances introduced in the free state into the blood of a living animal induces coagulation of it. The importance of these facts in regard to transfusion in human beings should not be overlooked.

Hitherto the transfusion of blood from an animal of the same kind has been referred to, dog's blood being injected into a dog. But when blood **from a different species** of animal is used symptoms of poisoning frequently develop. The urine is blood-coloured, and it contains albumen and tube casts; there is vomiting of bloody material, diarrhœa, etc. It is as if the foreign blood had acted as a poison, and we may inquire what is the nature of the poison. The observations of Ponfick and others have thrown considerable light on this matter. The urine is blood-coloured, but microscopic examination shows that this is due, not to the presence of red blood-corpuscles, but to that of the colouring matter of the blood in solution. It is not a bloody, but a blood-coloured urine; not a hæmaturia, but a **Hæmoglobinuria**. The fact seems to be that there is no poison in the foreign blood plasma, but that the corpuscles are unable to survive in the alien blood; they dissolve, and their hæmoglobin being dissolved in the plasma acts as a poison, and is eliminated by the kidneys. It seems to exercise its deleterious influence chiefly on the kidneys themselves, the tube casts and albumen in the urine being evidences of the irritation of these organs. The general symptoms, in fact, are largely referable to irritation of the kidneys.

It is to be observed that all animals are not exactly in the same relation to each other in this respect. It is found, for instance, that a much smaller quantity of lamb's blood than of hen's blood produces hæmoglobinuria in a dog. The importance of these facts in regard to transfusion in the human species will be apparent.

In this place it may be mentioned that the blood transfused does not, according to Panum, act as food or take its place. If an animal is undergoing starvation, transfusion does not avert or delay the process of inanition, it rather hastens it by increasing the waste. In using transfusion as a means of treatment the principal object is to make up the bulk of the blood, and this can be effected by the injection of serum or solution of common salt, with a small proportion of alkaline salt, making the solution near the specific gravity of the blood.

Plethora, as a pathological condition, is not of great importance. It may be presumed that in some persons the blood-forming organs,

Hæmoglobinuria is also of occasional occurrence in burns which involve extensive tracts of skin, also in pyæmia, in certain fevers, and, as a special form, in **Paroxysmal hæmoglobinuria.**

Hæmoglobinuria (*Hæmoglobinæmia*).—We have already considered at p. 457 the mode of occurrence of hæmoglobinuria when alien blood is transfused. It has been also produced artificially by the intravenous injection of distilled water, and biliary acids and by the hypodermic injection of diluted glycerine. Extensive burns of the skin, by destroying the vitality of the corpuscles in the vessels exposed to the high temperature, induce their ultimate solution. Certain poisons also partially dissolve the corpuscles, especially arseniuretted hydrogen and toluylendiamin. It occurs also in new-born children. (See under Icterus.)

Paroxysmal hæmoglobinuria is a condition in which the red corpuscles are peculiarly susceptible of solution, which is induced by slight causes. The commonest cause is exposure to cold, but a case is recorded in which it always occurred in a soldier after a long march. As exposure of the surface to cold is the usual cause, the affection occurs mostly in winter, but Rosenbach produced it in summer by a cold foot bath. The hæmoglobin is set free by the solution of the corpuscles. Ehrlich, in a case of this kind, put an elastic ligature round the finger and immersed the latter in ice-cold water. A drop of blood from the finger showed the corpuscles in various stages of decolorization, and also altered in size and shape (microcytes and poikilocytes). The urine in hæmoglobinuria gives a precipitate on heating like that of albumen, but this is hæmoglobin. The hæmoglobin is found in the urine in the form of little beads, often in rows, and sometimes forming casts of the uriniferous tubules.

The free hæmoglobin may stain the tissues, but this does not usually occur unless the hæmoglobin is transformed into hæmatoidin. The so-called hæmatogenous icterus, observed in pyæmia and other conditions, has this origin. (See under Icterus.) Recklinghausen found crystals of hæmatoidin in the blood in a case in which lamb's blood had been used for transfusion.

A more obscure mode of destruction is that which occurs in **pernicious anæmia,** where a progressive diminution of the red corpuscles is met with. That this is due to destruction of the red corpuscles is evidenced by the striking deposition of pigment in the liver which is characteristic of this disease.

(*b*) **Anæmia from defective formation of the corpuscles.**—This is the condition in **chlorosis,** where a defect in the blood-forming organs is probable. Secondary anæmias also belong to this category. In them there is some defect in the general conditions of life or some grave disease which, by lowering the nutrition as a whole, leads to defect in the blood.

2. **Character of the changes in the blood.**—From what has gone before it will be apparent that in the different forms of anæmia the state of the blood will vary considerably, and it will be proper to refer to each individually. The condition of the red corpuscles is the most important point. Their numbers may be estimated by one of the

forms of Hæmocytometer founded on the method of Malassez, and the amount of their hæmoglobin may be determined by the Hæmoglobinometer, in which the depth of colour is compared with a standard solution.

In **anæmias due to hæmorrhage**, in which a direct loss of the red corpuscles has occurred, the number of the corpuscles is reduced, and the plasma is watery.

Immediately after a severe hæmorrhage we have an actual **Oligæmia**, but this simple reduction in the bulk of the blood does not long remain, as various processes ensue which modify the condition of the blood. In the first place, the bulk of the blood is rapidly made up by absorption from the tissues and alimentary canal, and by diminution of the excretion of water by the kidneys. The result is that, while the bulk of the blood is made up, the plasma is watery and the red corpuscles deficient, a condition of **Oligocythæmia** and **Hydræmia**. In the blood, soon after a hæmorrhage, there is a certain proportional excess of white corpuscles, a **Leucocytosis**. This arises partly from the fact that the leucocytes, being more adhesive than the red corpuscles, do not escape so readily as these, and also because the leucocytes are more rapidly renewed than the red corpuscles.

If there has been a single hæmorrhage the blood is gradually, although slowly, restored. The plasma comparatively soon recovers its due concentration, but the red corpuscles are very slowly replenished, and it may be weeks or months before their number is made up. The condition of the blood itself will interfere with the activity of the blood-forming organs amongst the others. Where there are repeated, although small, hæmorrhages, a more or less permanent hydræmia and oligocythæmia result.

In **malarial fevers** and in conditions characterized by hæmoglobinuria, the conditions are similar to those resulting from hæmorrhage; there is a defect in the number of the red corpuscles.

Pernicious anæmia, or essential anæmia, is a condition in which, without apparent cause, the blood progressively deteriorates. In some cases which were supposed during life to present the features of this disease, post-mortem examination has revealed organic disease of the intestinal canal, such as a deep-seated cancerous tumour, or (according to Nothnagel and Fenwick) an induration of the stomach with atrophy of the gastric glands, or it may be the presence of intestinal parasites such as ankylostomum duodenale, bothriocephalus latus, but these cases ought to be removed from the present category, and to be assigned to the group of secondary anæmias of which they form striking examples.

The observations of Quincke, Peters, Russell, and others, which have been confirmed and elaborated by Hunter, show that in pernicious anæmia there is a great excess of pigment containing iron in the liver. This has been called by

Neumann hæmosiderin (see page 394). The iron is demonstrable by micro-chemical tests, sulphide of ammonium giving a dark colour, and ferrocyanide of potassium with dilute hydrochloric acid, the usual Prussian blue. The pigment is present chiefly in the outer two thirds of the hepatic lobules, and is contained in the hepatic cells (Fig. 275). The cells in the central parts of the lobules usually show fatty degeneration. A similar pigment is sometimes present in the kidney, where it is found mostly in the epithelium of the convoluted tubules. The bone-marrow also contains an excess of pigment in which iron is present. On the other hand, the spleen does not as a rule contain an excess of iron, although usually enlarged.

From these observations it may be inferred that in pernicious anæmia there is a great destruction of red corpuscles in the blood, the hæmoglobin not passing unchanged into the urine as in hæmoglobinuria, but being caught and stored, in an altered form, in the liver. Toluylendiamin, when injected into the blood of animals, induced a similar destruction of red corpuscles in the portal circulation and a similar accumulation of iron in the liver. In these experiments also there was no hæmoglobinuria. On the analogy of this poison, it is inferred by Hunter that pernicious anæmia is due to a poison absorbed from the intestine. It is not, however, necessary to infer that the destruction of the red corpuscles occurs in the portal vessels, as granular pigment in the general circulation is known to be deposited by preference in the liver.

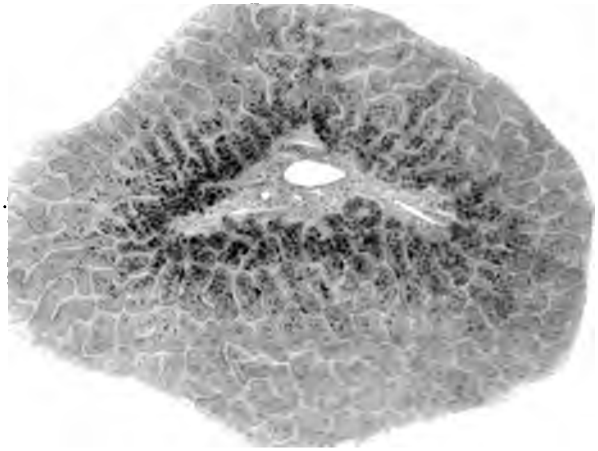

Fig. 275. – Liver in pernicious anæmia. The dark granules are blue in the specimen. They are in the cells in the peripheral parts of the lobules.

In this disease there is a marked deficiency in number in the red corpuscles; they have been found as few as 500,000 instead of 5,000,000 in the cubic millimetre. Although deficient in number, they are not usually defective in hæmoglobin. There may in fact be a relative increase of hæmoglobin. Besides this the red corpuscles show marked varieties in size and shape (see Fig. 7, Pl. II.). In most cases there are to be detected in the blood during life, small, globular, deeply-coloured red corpuscles, which are evidently altered red corpuscles. These have been named **Microcytes**. In addition forms considerably larger than normal red blood-corpuscles are found. These are called **Megalocytes**, or **Macrocytes**. There have also been observed red corpuscles of various forms (**Poikilocytes**). **Nucleated red corpuscles** are also occasionally present. These are young red corpuscles or erythroblasts (**Normoblasts**), and represent probably an attempt on the part of the blood to replenish those which have been destroyed. To the larger forms of these the name **Megaloblast** is given; to the smaller forms **Microblast**.

The condition of the spleen varies considerably; sometimes it is enlarged, it may be greatly so, sometimes it is scarcely at all altered. There may be also in it variously altered red corpuscles, as in the bone-marrow. In some cases the lymphatic glands are enlarged.

Chlorosis is a form of anæmia which occurs in females, usually about the time of puberty. The condition here is rather that of deficiency of hæmoglobin than of corpuscles, as the latter, although usually deficient in number, may not be so. The **achromatosis** may be such as to indicate that the hæmoglobin is reduced to a half or a fourth of the normal. The rapid recovery of cases of chlorosis under treatment with iron is consistent with the fact that it is not so much replenishment of red corpuscles as of hæmoglobin that is needed.

The occurrence of chlorosis at puberty has suggested as its cause some defect in the sexual organs, and there are cases in which the uterus or ovaries have been imperfect (Rokitansky). But in the majority of cases this is not so, and it is more probable that the changes at puberty develop the condition by throwing an extra strain on the blood-forming organs. Virchow has observed in cases of chlorosis certain congenital defects in the vascular apparatus, the chief of which are narrowness and thinness of the aorta, irregularity in the origin of the branches from the aorta, and smallness of the heart. The narrowness of the aorta may lead to compensatory hypertrophy of the heart in the same way as a narrowness of the aortic orifice. These lesions do not explain the chlorosis, but they suggest the existence of a congenital defect in the vascular system which may extend to the blood-forming organs, and may cause them to give way to the strain of puberty.

Secondary anæmias are generally due to grave exhausting diseases, such as phthisis pulmonalis, ulcerating cancers, Hodgkin's disease (which is also called **anæmia lymphatica**), leukæmia, fevers, albuminuria, etc. The condition of the blood in secondary anæmia is usually that of hydræmia or hypalbuminosis with oligocythæmia; the blood is watery and deficient in red corpuscles, but the remaining corpuscles are generally of normal colour.

3. **The condition of the bone-marrow in anæmias.**—In almost all forms of anæmia the bone-marrow shows alterations which vary in different cases, and are most extreme in advanced cases of pernicious anæmia. The normal bone-marrow is of two sorts: the red, which occupies all the bones in the fœtus and in young persons; and the yellow, which replaces the red in the shafts of the long bones in adult life, leaving the red in the cancellous tissue of the short bones and partly in that of the long bones. In anæmias, and more particularly in pernicious anæmia, there is a recurrence to the condition of red marrow in the shafts of the long bones, and there is frequently an atrophy of the bony lamellæ, so as to accommodate more of the altered marrow. We have thus, instead of the yellow adipose marrow, a red semi-fluid substance in which there may be no adipose cells, or only a few. As the normal red marrow is evidently an active tissue as compared with adipose tissue, and as the abnormal red marrow of anæmias is virtually of the same structure as the normal, it has been inferred that we have here a hypertrophy of the marrow. As the marrow is to be regarded as the principal source of the red corpuscles, the increase of its active tissue may be taken to imply an increased formation of red corpuscles. (See further under Bones and Joints.)

In the altered bone-marrow there is an increased number of nucleated red corpuscles or erythroblasts (Fig. 8, Pl. II.). Large and small forms may be seen with mitotic or fragmented nuclei. In some cases of long standing exceedingly large forms (*Gigantoblasts*) are found. The erythrocytes show the same variation in size and form observed in the blood. The large uninucleated marrow cells with their fine neutrophil or coarse eosinophil granules are readily recognised (Fig. 276). They are less numerous than in normal marrow. Cells containing disintegrating red blood-corpuscles are usually tolerably abundant. The myeloplaques or giant cells of the marrow are not evidently increased in number or size.

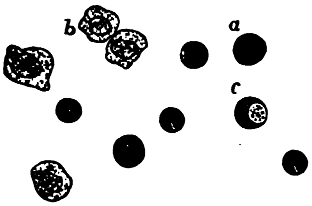

Fig. 276.—From red marrow which had replaced the yellow marrow of the shaft of the femur in Pernicious Anæmia. *a*, Nucleated red corpuscles. *c*, A red corpuscle with granular nucleus. *b*, Marrow cells with eosinophil granules.

4. **Other changes met with in general anæmias.**—The altered condition of the blood commonly induces other changes, which are not peculiar to any form of anæmia, but are liable to be more pronounced the greater the degree and the longer the duration of the disease. The condition of the blood interferes with nutrition and function, and

the most definite changes are degenerative, more particularly **fatty degeneration**. This manifests itself chiefly in the heart (see under Heart), but it also occurs in the walls of the blood-vessels. In this connection the frequency of hæmorrhages in pernicious anæmia should be borne in mind. In chlorosis and other anæmias a yellow figuring of the intima of the aorta due to fatty degeneration is frequently observed. (See under Diseases of Blood-vessels.) There may also be fatty degeneration of the epithelium of the kidneys (frequent in phthisis pulmonalis) and of the hepatic cells in the liver. There is also in some cases the change in the bone-marrow already referred to. Changes in the spinal cord in the form of sclerosis, sometimes extensive and often irregularly distributed, are not infrequent in pernicious anæmia and minute hæmorrhages into the brain, and meninges are sometimes seen.

Experiments on dogs show that successive large hæmorrhages rapidly produce fatty degeneration of the muscle of the heart. The author met with a case in man in which a single very severe hæmorrhage led to a very pronounced fatty degeneration of the heart, having the usual characteristic naked-eye appearances of that condition (which see).

Splenic Anæmia.—This is the name given by some to an uncommon form of profound, usually rapidly progressive anæmia, in which great splenic enlargement is an obvious feature. In cases of this kind there is no increase in the white blood-corpuscles as in Leukæmia (see further on); on the contrary there is frequently a decrease. The blood shows the changes met with in grave anæmia.

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WILLOCKS, Lancet, 1881; ROKITANSKY, Lehrb. d. path. Anat., vol. ii.; VON LIMBECK, Klin. Path. d. Blutes, 1896 (see also Literature, page 455); ALLBUTT (with literature), Syst. of Med., v., 1898; WEST (Splenic Anæmia), ibid., v., 1898.

III.—LEUCOCYTOSIS.

In this condition the number of leucocytes in the peripheral vessels of the blood is above the normal standard. The same holds true, as we shall see, in the case of Leukæmia. The two conditions are not therefore to be differentiated one from another by the number of leucocytes present in the blood, but rather by their nature. In the great majority of cases of leucocytosis, it is the polymorphonuclear leucocytes which are increased in amount, while in Leukæmia the increase affects other forms, and in addition there are present elements foreign to normal blood.

We have seen that the number of leucocytes in normal blood varies greatly, and that it is usually stated as from 6,000 to 10,000 per cubic millimetre. But many purely physiological conditions are capable of causing an increase. Thus, after violent exercise, during digestion, and in the later stages of pregnancy there is a **Physiological Leucocytosis**. In newly-born infants the number of leucocytes present in the blood is greater than in the case of adults. In some people it has been found that massage, electricity, and bathing in cold water induces a temporary leucocytosis.

The occurrence of leucocytosis is associated with various pathological conditions. **Pathological Leucocytosis** is of great importance and often of special diagnostic significance. Large losses of blood may induce, usually rapidly, a moderate leucocytosis (*Post-hæmorrhagic leucocytosis*). A large number of inflammatory lesions are associated with increase in the number of leucocytes in the blood (*Inflammatory leucocytosis*). As a rule the more virulent the process the more marked the leucocytosis. In severe cases of peritonitis, for example, the increase may be tenfold. In suppurative inflammations and septic processes generally it is well marked (Fig. 3, Pl. I.). The majority of the diseases already considered under the head of acute infective diseases are associated with leucocytosis (*Infective leucocytosis*). This is particularly the case with regard to pneumonia, diphtheria, smallpox, scarlet fever, anthrax, etc. The introduction into the body of various toxic substances, therapeutically or otherwise, is followed by an increase in the number of leucocytes in the blood (*Toxic leucocytosis*). Further, in most cases of extensive malignant disease and in many other cachectic conditions leucocytosis is present (*Cachectic leucocytosis*), while in many chronic affections a similar condition may develop shortly before death (*Terminal leucocytosis*).

It will be evident from the above enumeration that leucocytosis is a concomitant of many widely differing pathological conditions. It is equally important to bear in mind that in affections allied to those just mentioned leucocytosis may be absent. Thus in uncomplicated cases of typhoid fever, in influenza, measles, and many cases of malaria its absence may be of diagnostic value. In the case of the great majority of the many manifestations of tuberculosis the same holds true. Indeed, in most of the affections just mentioned the number of leucocytes may be considerably below the normal (*Leucopenia*).

As has been mentioned, the increase mainly affects the polymorphonuclear leucocytes, but an increase in the number of lymphocytes—**Lymphocytosis**—may occur. In the blood of newly-born children the leucocytosis is mainly a lymphocytosis, and in many diseases of infancy, especially gastro-intestinal affections, the same tendency has been noted. Post-hæmorrhagic leucocytosis is often associated with increase in the number of lymphocytes and a similar increase has been observed in rickets, syphilis, certain cases of malignant disease, and other cachectic conditions.

Further, a relative or absolute increase in the number of eosinophil leucocytes (**Eosinophilia**) may be present. This has been found in a large number of diseases due to the presence of animal parasites, *e.g.* trichinosis, ankylostomiasis, in a number of diseases of the skin, *e.g.* pemphigus, dermatitis herpetiformis, and in certain cases of malaria, sarcoma, asthma, osteomalacia, etc.

To determine the fact of leucocytosis is a comparatively simple matter. It is much more difficult satisfactorily to account for the presence of leucocytes in increased numbers in the blood. Most recent observers agree in regarding the phenomenon as, in part at least, a manifestation of chemiotaxis (see page 123). The leucocytes in the capillaries of the internal organs and especially in the bone marrow are attracted into the peripheral blood stream. Prior to the occurrence of leucocytosis there may be an actual leucopenia in the peripheral circulation. This is usually of short duration and is not present in all cases.

IV.—LEUKÆMIA. LEUCOCYTHÆMIA.

These terms mean literally white blood and white-cell blood, and they express a condition in which the blood is sometimes to an extreme degree light in colour, from the fact that the white corpuscles are in great excess. The excess of leucocytes is expressed by the term Leucocythæmia, originally applied by Bennett, but now generally discarded for Virchow's term Leukæmia. The disease is not, however, fully expressed by saying that the leucocytes are in excess. There is also diminution in the number of the red corpuscles, so that in this respect the condition might be classed as an anæmia.

Causation.—This is entirely obscure. There have been a few cases in which an injury to the spleen is supposed to have been the starting-point, while others have been ascribed to syphilis, rickets, malaria. The disease presents many features which suggest analogies with infective diseases and with tumour formation. The analogy of the tissue lesions with those in Hodgkin's disease, which belong to the former class, and with sarcomas, is consistent with this view. Cases have been recorded in which pernicious anæmia developed into leukæmia (Waldstein). The disease is twice as frequent in males as in females.

Character of the morbid changes.—The normal proportion of white corpuscles to red in the blood is stated, as we have seen, as about 1 in 300 to 1 in 450, but it varies within normal limits. In leukæmia, the relative proportion of white to red corpuscles is greatly altered. A case is not a very severe one in which the corpuscles are as 1 to 10, and they may be as 1 to 2, or even equal. The actual number of leucocytes not infrequently reaches 500,000 per cubic millimetre, or more than 50 times the highest normal average.

The blood presents considerable varieties in leukæmia in respect to the characters of the leucocytes present. Muir distinguishes two forms, according as large or small uninucleated cells predominate.

These may be conveniently treated under the heading of **Myelogenous** or **Myelogenic** and **Lymphatic leukæmia.**

Myelogenous leukæmia (Spleno-medullary).—In a large proportion of cases there is a great excess of large uninucleated corpuscles with oval or kidney-shaped nuclei (Fig. 4, Pl. I.). These cells, often called myelocytes or marrow cells, contain neutrophil granules (which are not normally present in the uninucleated leucocytes), or even basophil granules. Eosinophil cells of large size, like those just mentioned (Eosinophil myelocytes), and of the size met with in normal blood, are always found in increased numbers. The polymorphonuclear leucocytes are also increased. Along with the large uninuclear cells they form the bulk of the nucleated cells present. Nucleated red corpuscles, with rounded, fragmented, or mitotic nuclei, are always

PLATE II.

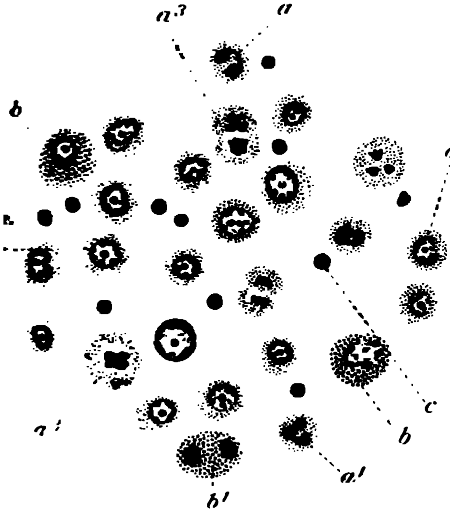

Fig. 5.—Bone Marrow in Myelogenous Leukæmia. × 600.

Film fixed by corrosive sublimate (wet method). Ehrlich's triacid stain. *a*. Polymorphonuclea rleucocyte. *a^1*. Transition form. *a^2*. Myelocyte. *a^3*. Myelocyte in mitosis. *b*. Eosinophil myelocyte. *b^1*. Eosinophil myelocyte in mitosis. *c*. Normal erythroblast.

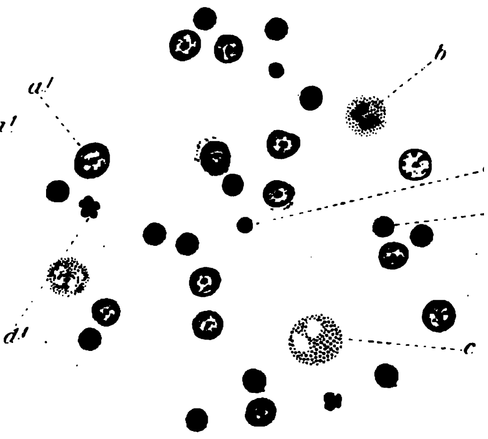

Fig. 6.—Blood in Lymphatic Leukæmia. × 600.

Jenner's stain. *a*. Small lymphocyte. *a^1*. Larger forms. *b*. Polymorphonuclear leucocyte. Eosinophil leucocyte. *d*. Erythroblast. *d^1*. Erythroblast with fragmentation of nucleus.

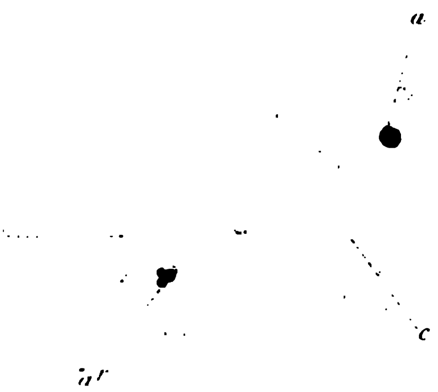

Fig. 7.—Blood in Pernicious Anæmia. × 600.

Hæmatoxylin and eosin stain. The erythrocytes show marked poikilocytosis. *a*. Megaloblast. *a^1*. Megaloblast with fragmentation of nucleus. *b*. Megalocyte. *c*. Microcyte.

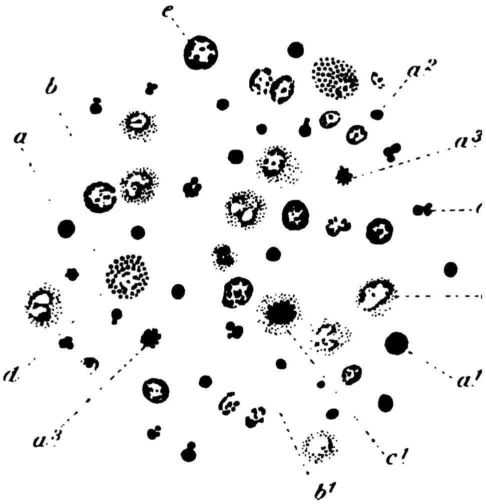

Fig. 8.—Bone Marrow in Pernicious Anæmia. × 600.

Film fixed by corrosive sublimate (wet method). Eosin and methylene blue stain. *a*. normoblast. *a^1*. Megaloblast. *a^2*. Microblast. *a^3*. Mitosis. *a^4*. Fragmentation of nucleus. *b*. Megalocyte. *b^1*. Microcyte. *c*. Myelocyte. *c^1*. Myelocyte in mitosis. *d*. Eosinophil myelocyte. *e*. Myelocyte with basophil granules.

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present, often in large numbers. Bloodplates are also increased in number. The small lymphocytes are not increased. As large uninucleated cells and eosinophil cells are abundant in the bone-marrow, this form of leukæmia has been regarded as primarily due to changes in the bone-marrow.

Lymphatic leukæmia.—In a smaller proportion of cases the so-called lymphocytes preponderate (Fig. 6, Pl. II.). There is little or no increase in the polymorphonuclear form, and the large uninucleated and eosinophil corpuscles are scarcely at all present. There are few cells except the lymphocytes, and hence the appearance is much more uniform than in the other variety. The lymphocytes present vary considerably in size. The larger forms may contain basophil granules. Nucleated red corpuscles are usually absent unless the anæmia is extreme. The number of bloodplates is, according to Muir, usually diminished. It might be supposed that in this form the lymphatic glands would be the chief primary seats of the disease, but this is by no means always the case. It seems more probable that more than one of the so-called lymphatic organs may be the seat of a special production of lymphocytes. This form is usually more quickly fatal than the other, the anæmia making more rapid advances. Cases described as acute leukæmia in young subjects are generally examples of lymphatic leukæmia. It is an interesting fact that not only does improvement in the general health lead to diminution in the number of leucocytes, but that acute febrile diseases, such as typhoid fever, milliary tuberculosis, influenza, septic fever, pneumonia, have a similar effect. The reduction is only temporary, and there is a rapid increase at the end of the fever. A similar temporary diminution in the size of the spleen and lymphatic glands occurs.

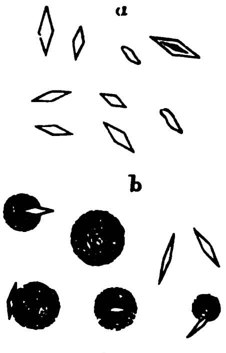

Fig. 277.—Charcot's crystals from the blood in leukæmia after death. In *b* the crystals are partly inside the white corpuscles. (ZENKER.) × 500.

In leukæmic blood, after death, there are found small, colourless, glancing crystals of an octahedral shape, which are usually called from their discoverer **Charcot's crystals** (Fig. 277). These are not found in the fresh blood and are not peculiar to leukæmia. Hypoxanthine and certain organic acids, *e.g.* lactic and formic acids, are sometimes found in considerable quantity.

The specific gravity of the blood is reduced in consequence of the low specific gravity of the leucocytes, as compared with the red corpuscles. It may fall from 1055 to 1040 or 1035. The blood has not a watery appearance as a rule. It is usually a thicker fluid than usual, and distinctly more opaque, resembling a mixture of pus and blood. It coagulates generally less rapidly than normally.

Nature of the disease.—Seeing that leukæmia is characterized by a great diminution in the red corpuscles and a great increase in the white, the natural inference was that it was due to a delayed or diminished conversion of white into red corpuscles. This was Virchow's original view, but is now generally departed from, as few hold that leucocytes are capable of giving rise to red blood-corpuscles. The disease evidently owes its origin to some marked alteration in the process of blood formation, and this is to be associated with changes in the blood-forming organs, especially the lymphatic structures and bone-marrow. The cause of this increased activity on the part of these tissues is quite unknown.

Tissue changes in leukæmia.—The changes in the blood are associated with lesions in the tissues, some of which are of primary, others of secondary importance. The most important changes are those which affect the organs generally regarded as concerned in the formation of the blood-corpuscles, namely, the bone-marrow and the lymphatic organs, like the spleen and lymphatic glands. Attempts have been made to divide the cases, according as the lesions have been chiefly in one or other of these organs, but this classification cannot be successfully carried out. The division here followed, and based on the characters of the leucocytes found in the blood, is more satisfactory.

The **Bone-marrow** undergoes changes which in some respects are similar to those in anæmias, but in other respects are different. The more common change is where a firm, pale, pinkish marrow is present; the less common where it is softer, yellowish white, and like pus. There is also in many cases an increase in the marrow at the expense of the osseous tissue, as in anæmia. In the myelogenic form there is a hyperplasia of the marrow with increase in the number of colourless elements (Fig. 5, Pl. II.). Thus, in a section of bone-marrow, we recognize the large cells of the marrow closely resembling those in the blood and containing either neutrophil or eosinophil granules, nucleated red corpuscles (Erythroblasts), and similar corpuscles of larger size (Megaloblasts), giant cells or myeloplaques of the marrow cells or red corpuscles in their anterior. Evidences of mitosis may be observed in the marrow cells. In the lymphatic form the marrow is overrun by small lymphocytes. There is a lymphocytic infiltration. Hæmorrhages and infarctions have been observed in the altered bone-marrow as in the spleen.

The Spleen is affected in most cases, and when affected it is in all stages enlarged. The enlargement is greatest and most constant in the myelogenic form. In the earliest period it appears to be due to an active congestion, and is accordingly of rapid development. Rindfleisch mentions a case which he saw at Virchow's demonstrations in which the enlargement had been so rapid as to cause a rupture of the capsule of the spleen. This enlargement is merely from overfilling of the vessels, but it is succeeded by, or develops into, a solid enlargement. The Malpighian bodies of the spleen have the structure of lymphatic follicles, and it is mainly by their increase in size that the permanent solid enlargement results. There is thus a great increase of lymphoid tissue. The spleen becomes converted into a hard, dense, bulky organ, sometimes like a piece of wood. It is also paler than normal, and we can often see the enlarged Malpighian bodies as whiter areas on the cut surface. In addition, there are frequently hæmorrhages in the spleen, and these may take the form of the regular wedge-shaped infarctions. The capsule of the spleen is thickened, and it presents not infrequently dense localized thickenings of a cartilaginous consistence. The capsule is often firmly adherent to the diaphragm and other neighbouring structures. The greatly enlarged, dense, and heavy organ is frequently dislocated downwards by its own weight.

The lesion in the **Lymphatic glands** consists in an enlargement of them. In the lymphatic form enlargement is the rule; in the myelogenic form it is usually more marked at the termination of the disease. This begins mostly in a particular set of glands usually situated externally, as in the axilla, groin, neck, etc., and spreads to other sets, generally first to those nearest. The enlarged glands may be three, five, or even ten times their normal size, but there is no tendency to any degeneration of their tissue.

A new-formation of lymphatic tissue, partaking more of the characters of tumour-formation, may occur in places where there is normally no such tissue present. In this case the term **lymphoma** is sometimes applied to the new-formation. More frequently, however, there is merely an infiltration of the connective tissue of organs with leucocytes.

The Liver is nearly always enlarged, and microscopic examination shows a great accumulation of leucocytes in the dilated hepatic capillaries. There is also in most cases a general infiltration of the capsule of Glisson, attaining to greater intensity at certain points, but it may be in such definitely localized areas as to suggest minute tumours.

The Kidneys are not infrequently affected, more especially in the lymphatic form. Here the appearance to the naked eye is often as if the organs were greatly enlarged by the presence of large pale tumours in the cortical substance. On microscopic examination (see Fig. 278) the lesion is seen to consist in an enormous infiltration of the stroma of the kidney with round cells, the proper secreting tissue remaining, but, of course, greatly pressed on. This infiltration occurs in definite areas, as if some agent had addressed itself to certain defined portions of the organ. The suprarenal bodies, thyroid gland, and ovaries may show in rare cases similar lesions.

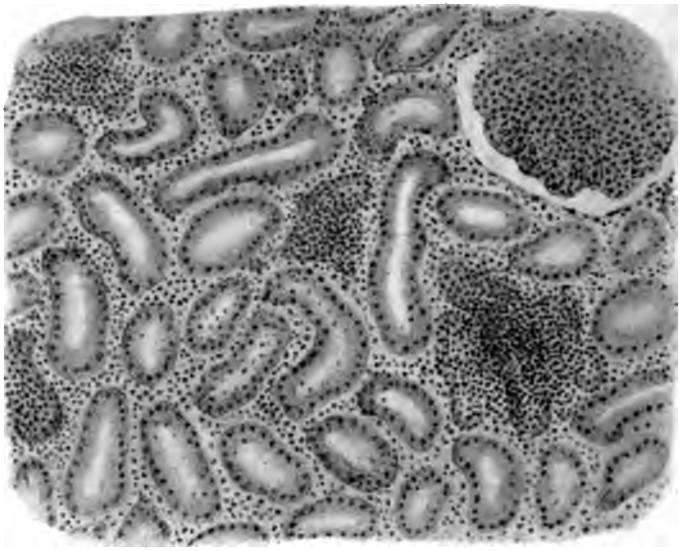

Fig. 278.—Kidney in leukæmia. A cellular infiltration is seen separating and partly obscuring the uriniferous tubules.

The **Closed follicles of the intestines**, both the solitary ones and those aggregated in Peyer's patches, may be enlarged, and as they are of lymphatic structure, their enlargement is a simple hyperplasia. Allied changes may be found in the thymus gland. These are not of frequent occurrence, and still less frequent is the formation of leukæmic tumours **in the skin**, these tumours consisting of infiltrations of round cells.

The connective tissue in other regions may also be infiltrated. The author met with a case in which the connective tissue of the mediastinum was enormously infiltrated, so that the tissue formed a bulky tumour. The infiltration extended to the pericardium much in the fashion of Hodgkin's disease.

It is proper here to mention that in **Hodgkin's disease**, which is sometimes called **Pseudo-leukæmia**, the organic lesions somewhat resemble those of leukæmia, but without the increase of white blood-corpuscles, the blood being simply anæmic. There is here also great enlargement of the spleen and of the lymphatic glands.

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SECTION II.

DISEASES OF THE ORGANS OF CIRCULATION.

A.—THE HEART AND PERICARDIUM.

I. **Congenital malformations**, chiefly of the heart and great vessels. **Causation.** Forms. Cyanosis a common result. II. **Coagula in the heart; the various** forms of thrombi. III. **Occlusion and stenosis of the coronary arteries.** Causes. Phenomena in acute and chronic obstruction. IV. **Retrograde changes.** (1) Atrophy, including brown atrophy, (2) Fatty infiltration, (3) Fatty degeneration, (4) Calcareous infiltration, (5) Other forms, (6) Injuries and rupture. V. **Hypertrophy and Dilatation.** Causes, including overstrain. Forms of hypertrophy. VI. **Inflammation.** (1) Myocarditis, parenchymatous, purulent, and interstitial, (2) Endocarditis, acute, chronic, and ulcerative, (3) Pericarditis, acute, chronic, and tubercular. VII. **Valvular disease.** (1) Insufficiency and (2) Stenosis of mitral, (3) Insufficiency and (4) Stenosis of aortic valves, (5) Valvular disease of right heart.

I.—CONGENITAL MALFORMATIONS OF THE HEART.

MISPLACEMENTS of the heart are of rare occurrence, and the more important of them are merely part of the general malformation of the body. The heart may be transposed, that is to say, placed in a position on the right side of the chest corresponding with that which it normally occupies on the left. With this there is usually transposition of the viscera, but it sometimes occurs alone. Again, the heart may occupy the middle line, as it does in early fœtal life. It may be placed outside the thorax altogether (*Ectopia cordis*), but in this case there are other congenital malformations, and that of the heart only forms a part (see Fig. 4, page 45).

Malformations of the pericardium.—Absence of the pericardium is a rare congenital malformation, and is mostly associated with ectopia cordis. There are, however, cases of absence of the pericardium in persons otherwise well formed. The sac may be entirely absent or there may be traces of it at the base.

Diverticulum of the pericardium is an unusual malformation. It occurs in the form of a sac with a narrow neck, which communicates with the pericardium. When distended the sac is about the size of a pigeon's egg.

Malformations of the heart and great vessels.—These for the most part represent survivals of fœtal conditions. The heart at an early period consists of two cavities, an auricle and a ventricle. The simple auricle receives the two venæ cavæ, and the ventricle gives origin to the common arterial trunk. The ventricle, the auricle, and the common arterial trunk subsequently undergo subdivision each into two. This separation in the *ventricle* begins near the apex; the septum gradually rises towards the base, its completion at the base being delayed after the rest of the septum has been formed. Rokitansky distinguishes two parts in the ventricular septum, namely, an anterior (*septum anterius*) which divides the orifices of the aorta and pulmonary artery, and a posterior (*septum posterius*) which comes between the two auriculo-ventricular openings. The **undefended space** (*pars membranacea*) is at the union of the anterior and posterior septa, and will be the last part to close. This portion of the septum remains throughout life devoid of muscular tissue, being composed of the two layers of endocardium from the two ventricles. It is situated at the base of the septum, just beneath the aortic valve. There is sometimes a minute aperture persisting in adult life. The common *arterial trunk* begins to show signs of division by a septum about the time that the interventricular septum is approaching the base. A septum passing from both sides of the artery meets and divides the vessel into what are subsequently the pulmonary artery and the aorta. These are so adjusted as to connect with the right and left ventricles respectively. The division of the *auricles* does not begin till the ventricular septum is nearly completed, namely, about the ninth week, and after being fully formed the septum remains partially open during the whole of intra-uterine life.

The **fœtal circulation**, so far as the heart and great vessels are concerned, differs from that of the adult chiefly in two respects, namely, in the existence of the foramen ovale and in the patency of the ductus arteriosus. The **Foramen ovale** forming a communication between the two auricles closes more or less completely at birth. The **Ductus arteriosus** connects the pulmonary artery with the descending aorta, and in the fœtus it conveys most of the blood going to the abdomen and lower limbs, as well as that to the umbilical arteries. The left ventricle and aortic arch thus supply in the fœtus the upper part of the body and the upper limbs, whilst the right ventricle and pulmonary artery through the ductus arteriosus supply the lower parts. There is a small part of the aorta between the origin of the subclavian artery and the opening of the ductus arteriosus, which is thus almost out of use in the fœtus. It is called the **Isthmus aortæ**, and is important in connection with subsequent lesions.

Consistently with the larger amount of work thrown on the right ventricle in the fœtus as compared with the adult, the wall of this ventricle is similar in thickness to that of the left ventricle

Causation of malformations of the heart.—A large proportion of cases of malformation are related to narrowness or **Stenosis of the pulmonary artery**. This has been variously ascribed to inflammation during fœtal life, and defective formation of the parts in the fœtus.

By some (Peacock, Meyer) inflammation occurring in early fœtal life has been assigned as the cause of the stenosis. We shall see afterwards that inflammation of the endocardium frequently leads to valvular lesions, which result in obstruction of the orifices. Occasionally at birth small nodular thickenings are met with in the valves. These are not evidently the result of fœtal endocarditis (see Fig. 279). In the adult, inflammation mostly occurs in the valves of the left side of the heart, and this is usually ascribed to the fact that the systemic arteries are liable to greater variations in blood-pressure and greater strain than the pulmonary vessels. In the fœtus it is otherwise; a much larger proportion of the circulation is dependent on the right ventricle, the abdominal aorta and umbilical arteries being fed by this ventricle. The umbilical arteries, again, are from their position, exposed to variations in pressure, and this may tell on the pulmonary artery at its origin.

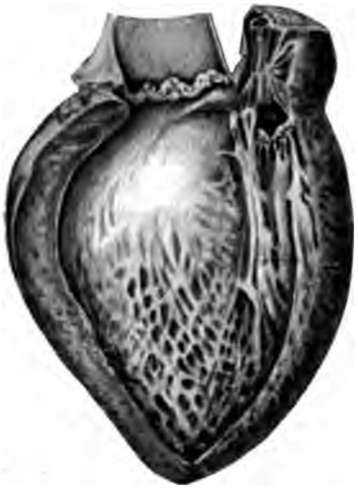

Fig. 279.—Nodular thickenings of the free edges of the cusps of the aortic and mitral valves. From a child 4 years of age. Slightly enlarged.

On the other hand, Rokitansky seeks to ascribe the frequency of defect of the pulmonary artery to deficiency in the original formation of the septum dividing the primary common arterial trunk. This is probably the more correct explanation, as there are seldom traces of inflammation visible in the endocardium at birth, and, besides, the lesion is not simply one of the valves, which inflammation produces, but frequently a real narrowing or defect in the artery, as if in the division of the primary arterial stem the greater part had been monopolized by the aorta.

The stenosis of the pulmonary artery is commonly associated with defects in the septa, and these may be ascribed to a mechanical interference with the complete closure of the septa. Let us suppose that the common arterial trunk, instead of dividing in a normal way into pulmonary artery and aorta, does so imperfectly, and so there is a large aorta and a small pulmonary artery, or even an entire absence of the latter. In the case last mentioned the blood from the right ventricle, as well as that from the left, would pass into the aorta, and the constant recurrence of this passage of blood at each systole of the ventricle would **prevent the closure of the septum** at the base, and cause the aorta to take permanent origin from the right ventricle as well as from the left. On a similar principle the obstruction of the pulmonary artery will, by raising the pressure of the blood in the right auricle, interfere with the closure of the foramen ovale.

Instead of stenosis of the pulmonary artery, we may have a similar condition of the aorta. The consequence of this will be defect of the septa and alterations in the circulation, the latter differently located to those already mentioned.

Forms of malformation.—1. Defects of the septum ventriculorum.—As already indicated, this usually goes along with defect of the great vessels. When the stenosis is in the pulmonary artery, as is mostly the case, it is chiefly the anterior part of the septum which is defective; while in the case of aortic stenosis it is the posterior (Rokitansky). The defect, if limited in extent, is usually in or near the **undefended**

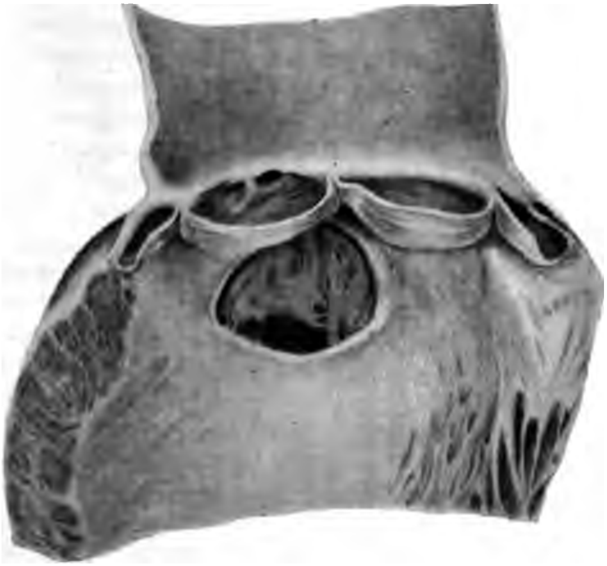

Fig. 260.—Defect of interventricular septum. The gap is situated at the base in the position of the undefended space. A portion of the tricuspid valve is seen through the aperture.

space (see Fig. 280). In some cases the defect may be in the muscle of the posterior part of the septum (see Fig. 281). The defect may be so great as that there is virtually no septum, the ventricle being composed of a single cavity, or it may present various degrees of divergence from this extreme.

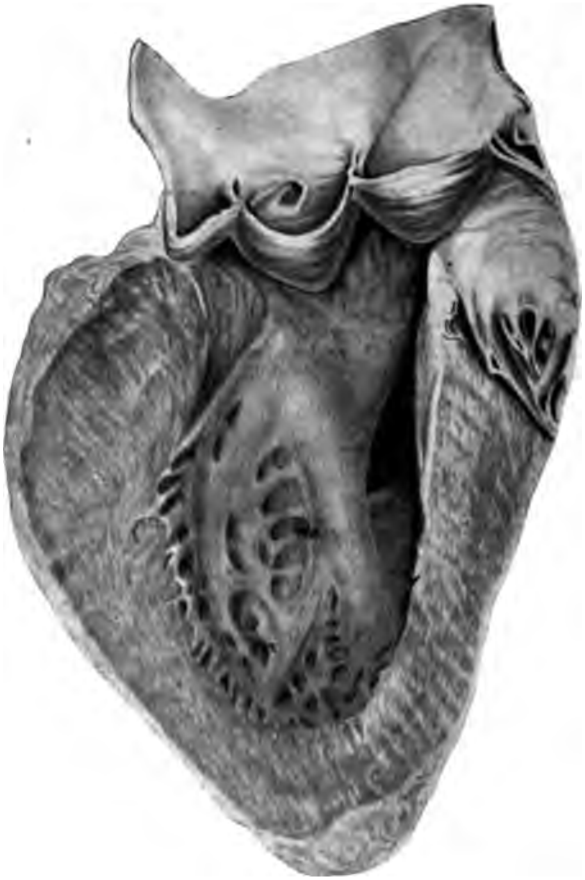

Fig. 281.—Defect of the interventricular septum. The gap is situated in the muscle of the posterior part of the septum.

2. **Defects of the septum auriculorum.**—The least degree of defect of this septum is the persistence of the foramen ovale. A certain degree of this is very frequently present in adult hearts, but the aperture is usually so small or so valved that there is virtually no communication between the contents of the two auricles. The fenestra ovalis is sometimes seen to bulge into the auricular

cavity (see Fig. 282). On the other hand, the lesion may be connected with stenosis of the pulmonary artery or aorta, and in that case there is an actual and persistent communication between the two cavities.

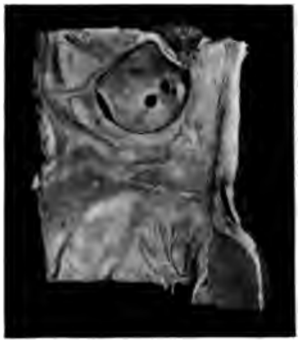

Fig. 282.—A bulging Fenestra ovalis is seen with several foramina.

In more extreme cases the septum itself is defective. It may be entirely wanting, or defective at its lower part. This lesion frequently coincides with a defect of the posterior ventricular septum.

3. **Congenital stenosis of the pulmonary artery.**—This may be to a slight or to an extreme degree. (See Fig. 283.) In most cases the ventricular and auricular septa are also defective. (Kussmaul in 192 cases found the ventricular septum complete in only 21.) The most extreme case is that in which the pulmonary artery is entirely wanting, and the aorta receives the blood from both ventricles. In this case the lungs are supplied from the aorta by means of the *Ductus arteriosus Botalli*, which remains patent, the blood passing, however, in the reverse direction to that which obtains in the fœtus. In its minor degrees stenosis of the pulmonary artery may be associated with a complete ventricular septum, but the foramen ovale is likely to remain open. Stenosis of the pulmonary artery leads to hypertrophy of the right ventricle just as a similar obstruction does in the adult.

4. **Congenital stenosis of the aorta.**—The narrowness may be at its origin or at the isthmus aortæ. In the former case there is usually defect of the septa as already explained. Stenosis of the aorta, even amounting to obliteration (atresia) may have little effect on the circulation during fœtal life, the systemic circulation being carried on by the pulmonary artery through the ductus arteriosus. But at birth, as there is a great increase in the amount of blood coming to the left auricle by the opening up of the pulmonary circulation, the left ventricle may have great difficulty in dealing with it. In cases of **stenosis of the isthmus aortæ** the circulation is assisted by anastomosis between the subclavian artery and the thoracic and abdominal aorta. The narrowness of the aorta at the isthmus may give rise in later life to aneurysm above the seat of narrowing.

5. **Persistence of the ductus arteriosus Botalli.**—This communication between the pulmonary artery and thoracic aorta is normally completely closed within two, or at most three, weeks after birth. It

may, however, remain patent when from any cause the circulation is abnormally directed through it. This may occur by reason of obstruction of the pulmonary artery (see Fig. 283) or aorta, or from stenosis of the mitral orifice. It has also been observed without any other malformation in cases of obstruction to the pulmonary circulation from insufficient inflation of the lungs (atelectasis). Aneurysmal dilatation of the vessel has been observed.

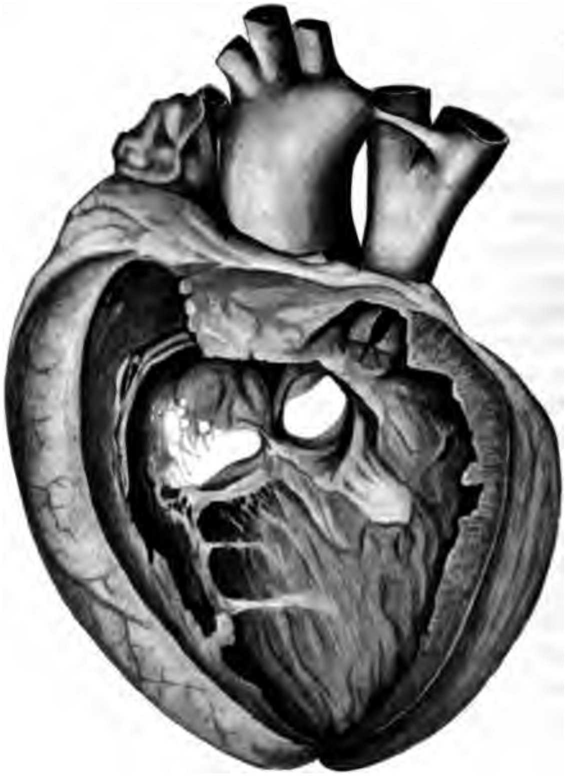

Fig. 283.—Congenital stenosis of the pulmonary artery, with hypertrophy of the right ventricle. There is a large aperture in the interventricular septum. A well-marked ductus arteriosus is present.

6. **Transposition of the great vessels.**—This consists in a reversal of the relative positions of pulmonary artery and aorta, so that the former takes origin from the left ventricle and the latter from the right. The blood from the systemic veins is sent directly into the aorta without first passing through the lungs, and the right ventricle undergoes hypertrophy, and becomes like the left. In such cases the conditions of life are very unfavourable, and yet in one case life was

prolonged for three years. Rokitansky has pointed out that even though the great vessels may be transposed, the position of the ventricular septum may be so altered as to restore the normal connections with right and left ventricles respectively.

7. **Malformations of the semilunar valves.**—Malformations of the aortic or pulmonic valves may be part of congenital lesions of the main vessels themselves, but are frequently of independent origin. The valve may be in the form of a diaphragm in which there are merely indications of a tripartite formation (see Fig. 284). In this case the diaphragm is often protruded into the vessel in the form of a funnel. Again, we not infrequently meet with some variety in the size or number of the semilunar folds. There may be only two curtains, usually a large and a normal one, the larger one commonly showing indications of a partial division (see Fig. 285). Then with three curtains there may be two large segments and a small rudimentary one between them.

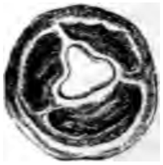

Fig. 284.—Congenital adhesion of the curtain of the pulmonic valve. The valve is viewed from above. (PEACOCK.)

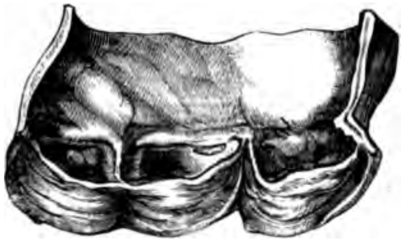

Fig. 285.—Congenital malformation of aortic valve. There are two curtains, but the larger one shows a partial division. (PEACOCK.)

Many of these malformations are probably to be referred to endocarditis occurring in the fœtus. In adult life endocarditis often produces adhesion of the curtains, but there is also very great contortion of the valves. But, in the fœtus, the plastic power and adaptability of the structures is much greater, and the three coalesced valves may form a well-shaped diaphragm, or the two a single larger semilunar fold. In either case there are still indications of the coalescence in the form of thickenings along the line of union.

It is obvious that these malformations will frequently interfere with the functions of the valves. In the extreme cases of complete union of the three curtains (as in Fig. 284) there will be great obstruction as well as imperfect closure. When there are only two curtains, the middle part, where coalescence has occurred, is thicker, and the curtain may be more rigid at this point, and so its function will be interfered with.

According to Peacock, congenital malformations of the valves are apt to lead to more definite disease from endocarditis in after-life. This may be a recurrence of a fœtal endocarditis, but, in addition, the imperfect adaptation of the valves may itself give rise to a certain irritation and predispose the structures to inflammation. So it happens that valves malformed in this way are peculiarly prone to disease in after-life, even although their function is not at first imperfect.

Besides the variations already noted the curtains of the aortic and pulmonic valves are sometimes **abnormally numerous**, especially those of the latter. There may be four curtains instead of three, and they may present all varieties of size relative to one another. (See Fig. 286.)

The semilunar valves sometimes present a condition somewhat **approaching that of the cuspid form**. It is to be noted that during the closure of a semilunar valve the curtains do not come in contact by their free margins, but that the line of contact is somewhat removed from the margin. During closure, therefore, when the artery is full, a certain portion of the curtain floats free in the blood. This portion between the line of contact and the free margin is frequently the seat of apertures or fenestrations, and that without affecting the function of the valve. This fenestration may be very extreme and may graduate towards a condition in which (see Fig. 287), instead of a piece of tissue, there is merely a series of tendinous bands passing from the curtain, near the line of contact, to the wall of the vessel at the point of insertion of the curtain. These tendinous bands resemble the chordæ tendineæ of the cuspid valves, and the resemblance may be increased by the neighbouring edges of the curtains being joined, and the tendinous bands from the adjacent borders of two curtains passing together to the wall of the vessel. There may even be on the wall of the vessel an elongated prominence into which the bands are inserted, and resembling a musculus

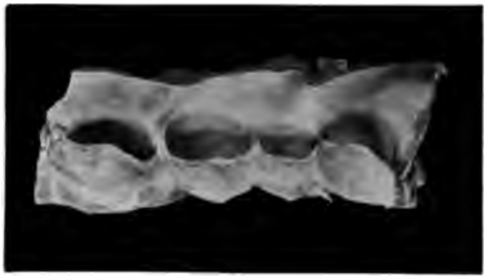

Fig. 286.—Pulmonic valve with four cusps.

papillaris (see figure). These bands may have a considerably free course from the middle of the curtain to the wall of the vessel. A certain amount of this condition is very frequent in both the aortic and pulmonic valves.

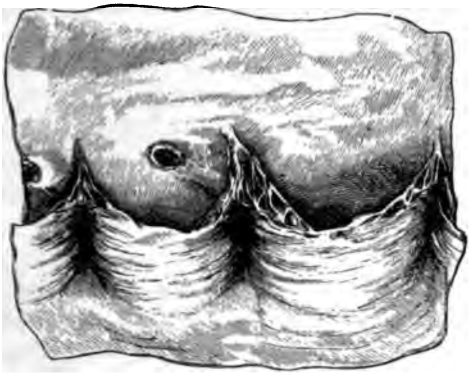

Fig. 287.—Fenestration of the marginal parts of the aortic valve. There is an appearance of chordæ tendineæ, and the bands from two proximal curtains are inserted into a projection from the aorta.

It may be asked, Does such a malformation interfere with the function of the valve? Probably not much, but still to a certain extent. Each form of valve is appropriate to its own place. The cuspid form is adapted to an aperture between two cavities, the semilunar to the orifice or course of a vessel. The latter takes up less room, as in it, by reason of their complete separation, the curtains fall back completely when the blood rushes past. But if the valve approaches to the cuspid form, especially if the margins of the curtains are united, and the tendinous bands from two have a common insertion, then there can hardly be that complete falling back which occurs when the structure is perfect. This will probably cause a trivial obstruction, but the curtains being unduly exposed to the force of the wave of blood may be specially liable to inflammation.

8. **Congenital malformation of the auriculo-ventricular valves.**— These valves are, like the semilunar valves, occasionally the seat of malformations which usually cause narrowing of the orifice. This may be in the form of coalescence of the curtains, produced, in some cases, probably by a fœtal endocarditis, so that in place of the valve there may be a more or less immobile diaphragm. The affection is observed chiefly in the right auriculo-ventricular valve. It will produce somewhat similar effects to those induced by stenosis of the pulmonary artery. There will be patency of the foramen ovale, and the blood from the venæ cavæ will, in part or wholly, pass through this foramen into the left auricle, thence into the left ventricle, and then, through a defect in the septum, partly into the right ventricle, so as to supply the pulmonary artery. Abnormalities in the number of cusps are sometimes

met with. Greenfield has recorded a case in which two mitral valves were present. The writer has a specimen of a mitral valve with three cusps found in the heart of a horse.

Cyanosis.—Morbus cæruleus.—Children born with malformations of the heart are usually liable to symptoms connected with the respiration and circulation, which are in many respects comparable with those from valvular disease acquired in after-life, and consist chiefly in attacks of dyspnœa and lividity. These symptoms may occur at birth or soon after it, but they may be postponed for years, and develop apparently by some extra stress laid on the circulation, or they may not develop at all. Occurring at first intermittently the dyspnœa and lividity very often, to some extent, become permanent. This is particularly true of the lividity, which frequently forms such a marked characteristic of such persons that they are visibly the subjects of Cyanosis or Morbus cæruleus. The lips and finger-nails appear blue, and there is, perhaps, a deep lividity of hands, feet, and cheeks as well.

Two explanations of this symptom have been offered. The first is that, as in these cases the septa of the heart are mostly imperfect, the lividity results from the mixing of the currents, venous blood being mixed with the arterial in the systemic vessels. This looks a very likely explanation, but there are two serious objections to it. Cyanosis has been found in cases where the currents did not mix, and it has been absent where they undoubtedly did. Besides this, it is found that the degree of cyanosis is not at all proportionate to the mixing of the currents. The other explanation is that the cyanosis is due to venous engorgement, just as lividity occurring in valvular disease in the adult. In nearly all the cases there is obstruction of the pulmonary artery, which we have seen to be at the basis of most malformations, and this has the effect of bringing about a general venous engorgement. During the early periods of life the blood-vessels are yielding and plastic, and so the permanent congestion tells much more on them than it does in adult life. Cyanosis developed in after-life sometimes approaches in intensity to that from malformation, but it rarely reaches it.

Duration of life in malformations of the heart.—If there is merely slight imperfection of the septa, the defect is of little importance, and we have already seen that there is imperfect closure of the foramen ovale in a very considerable proportion of the cases met with in the ordinary course of post-mortem examination. If there is moderate contraction of the pulmonary artery while the heart is otherwise well formed, the right ventricle will probably hypertrophy, and this may almost completely compensate, so that life is scarcely shortened. If the foramen ovale is distinctly patent, this generally implies a greater degree of obstruction of the pulmonary artery, and life is usually abbreviated. Peacock has collected twenty cases of this kind, and only eleven of these lived to the age of 15 and upwards, but some lived as long as 34, 40, and 57. In three cases the ductus arteriosus was also open, and these died at the ages of 10 months, 15 months, and 29 years. If the interventricular septum is imperfect, this implies an obstruction at an earlier period of fœtal life, and the duration of life is shorter. Of sixty-four cases, only fourteen survived the age of 15, but still three lived as long as 25, and one 39 years. Where the pulmonary artery is entirely impervious the duration of life is still shorter; of twenty-eight such cases only seven lived over a year, and the longest duration was 12 years. Where there is still greater arrest of development, and the heart consists of but one ventricle, with one or two auricles, the period of survival is usually very limited, but it is interesting to find that four persons thus affected have lived to the ages of 11, 16, 23, and 24 years. Transposition of the pulmonary artery and aorta might appear to be a malformation almost incompatible with life, and yet of twenty-one such cases four lived between 2 and 3 years. When the aorta is obstructed at its isthmus, and the descending aorta is supplied, wholly or partially, by the pulmonary artery, the duration of life is usually very limited. The lungs are deprived of blood, because it passes to the abdominal aorta, and the children die with symptoms of dyspnœa and syncope. If the obstruction, however, be only slight, the person may survive to adult or middle life, even though the ductus arteriosus remains pervious; thus there are cases of survival to 24, 32, and 43 years of age. If the constriction be so slight that the ductus arteriosus closes, it may yet become much more considerable afterwards, or the aorta may even be obliterated at the point indicated. Yet such patients may survive long, as even with obliteration the ages of 45, 50, and 57 have been attained.

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II.—COAGULA IN THE HEART.

Thrombi in the heart are of frequent occurrence; they vary in kind and in significance. Most of the forms of thrombi have been already referred to (see p. 78). Thrombi are frequently designated **vegetations**, but it is not advisable to use this word in the place of the more accurate one thrombi. We may distinguish three forms of thrombi:—warty, globular, and polypoid.

Warty thrombi occur in acute endocarditis, owing to the coagulation of the fibrine on the inflamed and roughened surfaces. (See further on.)

Globular thrombi are of common occurrence in dilated and hypertrophied hearts, originating in the retired parts of the cavities, such as the auricular appendages (see Fig. 288), the apices of the ventricles,

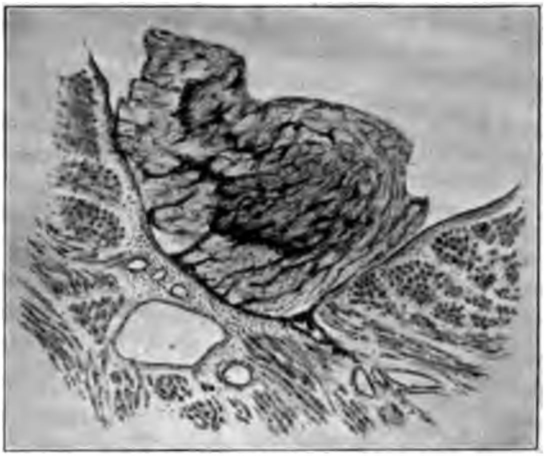


Fig. 288.—Thrombus in the auricle of the heart. The muscular tissue is shown in longitudinal and transverse section and lining it the endocardium. The thrombus bulges out from a recess. × 42.

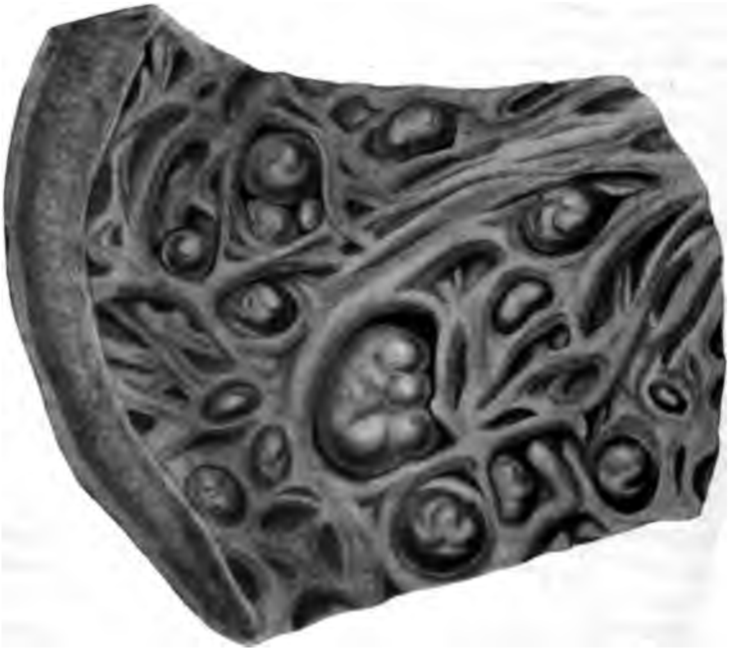


Fig. 289.—Globular thrombi from near the apex of the left ventricle. Several these are seen to project from between the musculi papillares.

and behind the columnæ carneæ. (See Figs. 289 and 290.) They are usually multiple, and the smaller of them may appear as pearly white bodies presenting a rounded projection between the trabeculæ. They may, however, grow out from these positions, and assume considerable dimensions. It is not uncommon to find them distending the auricular appendage, and sometimes filling the greater part of the auricle. The larger ones soften in the centre, forming a whitish or brownish juice, resembling pus in its naked-eye characters, but consisting merely of debris (see Fig. 290). It is quite common to find the thrombus converted into a sac, composed of a thin rind and a cavity filled with this puriform fluid. Rupture may occur during life and pieces of the thrombus may be torn off, or a thrombus may be detached bodily and carried into the pulmonary artery or aorta, so as to produce embolism. The globular thrombi are most common in the right auricle and ventricle, as these cavities are more liable to dilatation than those of

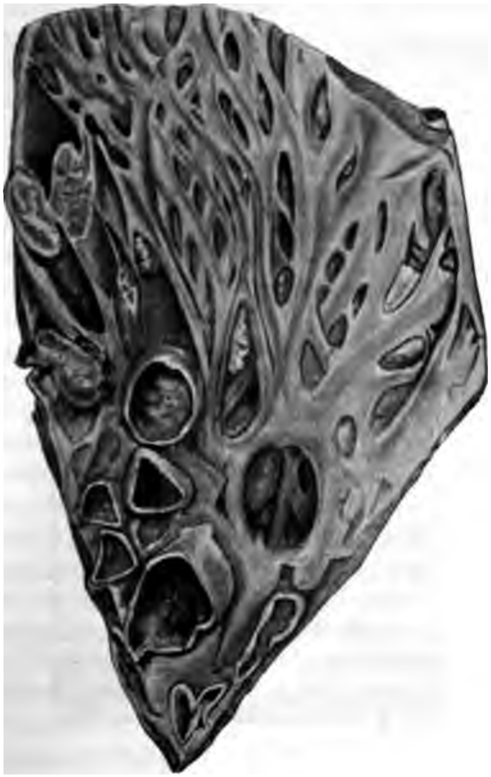


Fig. 290.—Softening of thrombi. From the wall of the right ventricle.

the left, hence embolism is more frequent in the lungs than in the systemic system. The formation of thrombi in the right cavities often coincides with thrombosis in the veins, as causes which induce dilatation of these cavities are similar to those which lead to general venous hyperæmia. Hence in a particular case of pulmonary embolism it may be a question whether the source is in the right heart or in the veins.

The **Polypoid thrombi** are much more uncommon than the other two forms. It sometimes happens that a thrombus is formed on a valve or on the internal surface of the heart and from this point grows out by successive deposition to a considerable size. The author has met with a case in which the left ventricle was filled with massive festoons thus formed, and great hypertrophy and dilatation had occurred. In this case also the coagula had undergone a partial impregnation with lime. There is also a case recorded by Gairdner in which a thrombus, formed of firm fibrine and attached to the wall of the right auricle, hung free in the auricle and assumed a nearly globular form (see Fig. 292). It was so placed as to hang down into the tricuspid orifice, which it greatly obstructed, like a ball-valve.

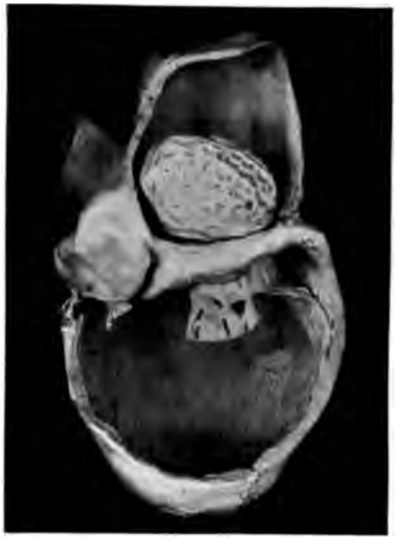


Fig. 291.—Globular thrombus in left auricle.

A somewhat similar case is recorded by Allan Burns as having occurred in the Royal Infirmary, Glasgow. In Fig. 291 is shown a globular thrombus in the left auricle obstructing the mitral orifice.

In the first of the cases referred to above, the left ventricle was occupied by a large firm fibrinous mass, which consisted of twelve or thirteen polypoid coagula having a firm attachment to the anterior wall of the ventricle at about its middle. It was estimated that these coagula weighed two ounces. The coagula were obviously old and the basal parts had undergone a kind of fibrous transformation resembling tendon, while the red part looked like the fleshy part of a muscle. There was no softening, but in the substance of the polypus and partly on its surface, a somewhat massive deposition of lime salts had occurred, forming at one place a sort of stem an inch in length. (The specimen is in the museum of the Royal Infirmary, Glasgow.)

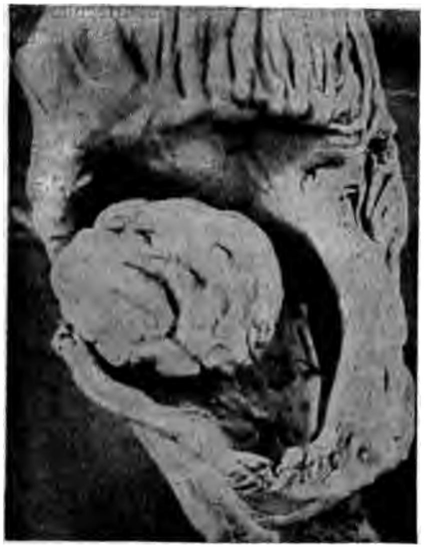


Fig. 292.—Thrombus in right auricle. It is drawn up so as to be displayed, but in its natural position it fell down like a ball over tricuspid orifice.

The second case is one in which a stenosis of the tricuspid valve had been diagnosed by Sir William Gairdner many years before death. (This unique specimen is in the museum of the Western Infirmary, Glasgow.)

Polypoid thrombi of large size may sometimes become detached. They are often spoken of as **Ball Thrombi**. In some cases they become calcified throughout, forming the so-called **Cardioliths**.

Literature.—Allan Burns, Dis. of heart, 1809; Steven and Coats, Glasg. Med. Jour., Feb., 1870; Gairdner, Clin. Med., 1862, and Edin. Hosp. Reports, 1893; Wickham Legg (Loose balls of fibrine in left auricle), Path. Trans., xxix., 49; Delépine (Cardiolith), Path. Trans., London, li., 1890; Welch (literature), Allbutt's Syst. of Med., vi., 1899; Martin and Rennie, Lancet, ii., 1899.

III.—OCCLUSION AND STENOSIS OF THE CORONARY ARTERIES.

The coronary arteries are frequently affected either at their orifices or in their course by lesions which interfere with the circulation through them. As these arteries are, at the most, possessed of very imperfect anastomosing communications, obstruction implies a very serious disturbance in the function of the heart, amounting, in the case of a sudden obstruction of a large branch, to sudden paralysis of its action and death.

Cohnheim asserts that the coronary arteries are end-arteries. Ligature of one of the larger branches in the dog produced first irregularity and then stoppage of the heart in from thirty seconds to a minute. Wickham Legg and West believe that there are free anastomoses between the branches of the arteries, while Steven asserts that there are communications, but only among the finest arterioles. The author is convinced, from observation of Steven's injections, that the communications are of the very finest vessels, partly capillaries and partly minute arteries.

Causes of obstruction of the coronary arteries.—These arteries are peculiarly liable to **Atheroma**. Perhaps the fact that, coming off directly from the aorta, they are exposed to higher pressure and greater variations of pressure than other arteries of their size, may account for this. Atheroma, as explained further on, leads to narrowing of the calibre of the artery, and it often induces **Thrombosis** which may increase the stenosis or even lead to occlusion. This is most common where calcareous infiltration follows atheroma. After a prolonged stenosis there may be a sudden complete occlusion. Again, atheroma sometimes leads to a small aneurysm of the artery. **Atheroma in the aorta** leads not infrequently to **Obstruction of the orifices of the coronary arteries**. The aorta is the most frequent seat of atheroma, and as this condition leads to thickening of the internal coat there will sometimes be a bulging of this coat over the orifices of the coronary arteries. Not infrequently the prominent intima around the orifice coalesces and completely covers the aperture. **Syphilis** sometimes causes narrowing of the calibre of the coronary arteries, the condition resembling what occurs, with much greater frequency, in the arteries of the brain (see further on).

Embolism is also liable to occur in the coronary arteries. It used to be stated that during the systole of the ventricle the coronary arteries were closed by the curtains of the aortic valve falling against them. It is stated by recent observers, however, that this is not the case, and that the orifices are exposed during the systole, and hence, in cases of acute endocarditis, small portions of thrombi are liable to pass into the coronary arteries. The arteries obstructed will nearly always be small, and the obstruction is often multiple. In ulcerative endocarditis and pyæmia there may be septic embolism and the formation of abscesses.

Effects of obstruction of the coronary arteries.—The results vary somewhat according to the suddenness of the obstruction, the size of the vessel, and otherwise.

Sudden obstruction of a considerable branch, usually brought about by thrombosis occurring in consequence of atheroma, leads to **Infarction of the heart.** The affected area is usually in the wall of the left ventricle, the artery most frequently obstructed being the descending branch of the left coronary artery. If death occurs immediately after the obstruction the part will be found of normal consistence, but pale yellow in colour. Very soon it becomes soft and yellowish white or brown in colour, and the part is depressed below the surface. In some cases the part becomes almost fluid. This condition of softening, which has been called by Ziegler **Myomalacia cordis**, may be associated with hæmorrhage. Under the microscope the muscular fibre is found more or less broken up, its transverse striæ have disappeared, and the fibres have assumed a hyaline or waxy appearance (waxy degeneration or coagulation-necrosis). There is often, at least in the peripheral part, a great infiltration of leucocytes, from inflammatory reaction.

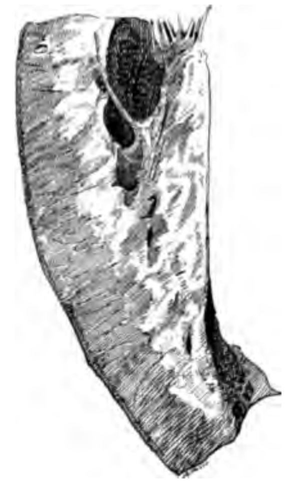


Fig. 203.—Section of left ventricle and a musculus papillaris showing fibrous transformation.

The softened portion of the wall may give way before the pressure of the blood, and the result may be an **Acute aneurysm** of the heart or even **Rupture.** The condition under review is probably the most frequent cause of rupture of the organ.

If the patch of softening be small, then through time the muscular tissue is absorbed and the connective tissue is increased in the way to be described further on.

A more **Chronic obstruction** of a considerable branch or a sudden obstruction of a smaller branch, frequently leads to a condition which has been designated **Fibrous transformation**, or (less happily) fibroid degeneration. This condition is really that present in most cases of so-called **Interstitial myocarditis.** The gradual or more sudden deprivation of blood causes atrophy and degeneration of the muscular fibres, and the connective tissue comes to form the chief or entire constituent of the heart-wall, generally reinforced by a certain new-formation due to chronic inflammation. The patches of fibrous transformation vary greatly in size according to the artery obstructed. They may be simply small tendinous areas in the midst of the muscle (see Fig. 293), or they may affect extensive tracts (see Fig. 294). The tendinous or cicatricial appearance is sometimes visible in the musculi papillares when the ventricles are laid open, but it may only be discovered by slicing the muscular tissue, which is best done by sections parallel to the surface of the heart (see Fig. 295). Where an extensive area has undergone this transformation the wall of the heart may be bulged outwards, thus forming a **Chronic aneurysm** of the heart (see Fig. 296). Under the microscope the fibrous patch consists chiefly of wavy connective tissue with very little appearance of inflammation. There may be no muscular tissue in the midst of the patch, but sometimes atrophied fibres may be visible (see Fig. 297).

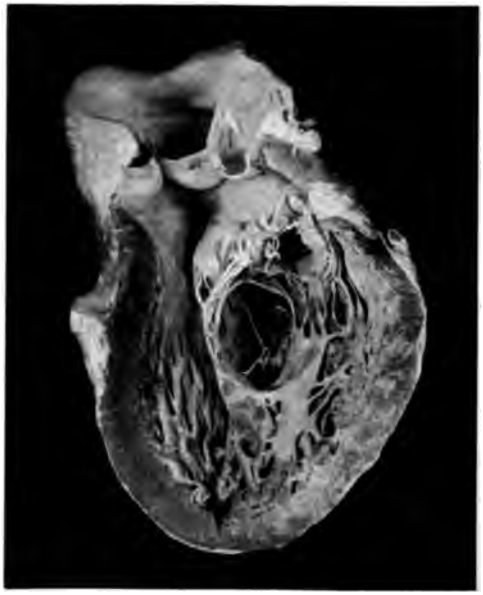


Fig. 294.—Fibrous transformation of the left ventricle of the heart in Syphilis. Two sections of the left coronary artery are shown. The vessel is almost entirely occluded.

Fatty degeneration is also a result of obstruction of the coronary arteries. This is most pronounced in cases of obliteration of the orifice of one or both arteries by atheroma of the aorta.

In a case observed by the author where one orifice was completely occluded and the other somewhat narrowed, there was generalized and typical fatty degeneration such as one sees in pernicious anæmia. There was here a slowly advancing

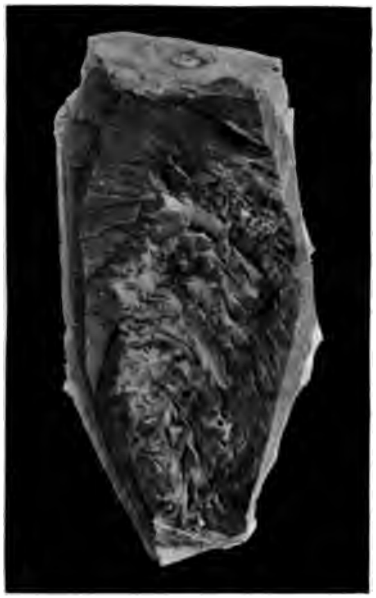


Fig. 285.—Fibrous transformation of left ventricle. The atheromatous coronary artery is shown on section in the upper part of the illustration.

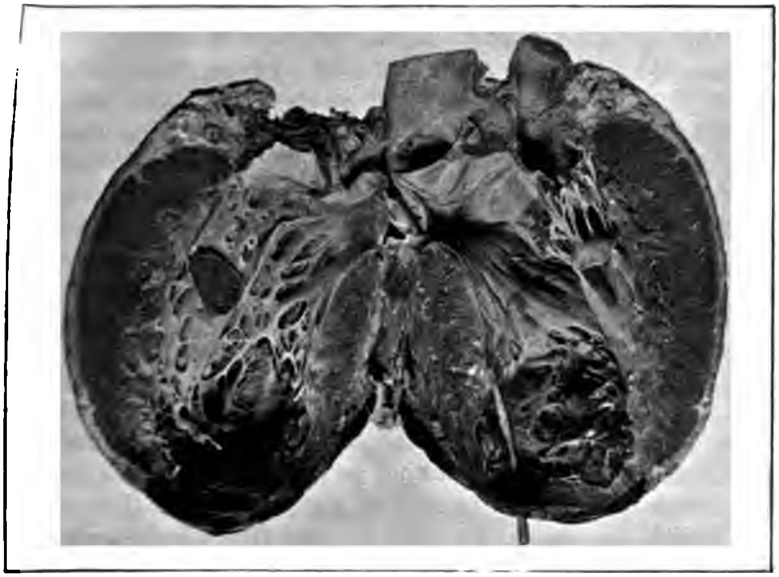


Fig. 286.—Aneurysmal dilatation of apex of heart. Rupture of left ventricle. A rod is passed through the rupture.

deprivation of blood, which only proved fatal when very extreme. Greenfi recorded a case in which both arteries were occluded, and in which he su that the heart might be partially nourished by imbibition.

It is clear that during life there will often be, in consequence obstruction of the coronary arteries, serious functional disturba the heart. There may be urgent dyspnœa, pain and irregularity

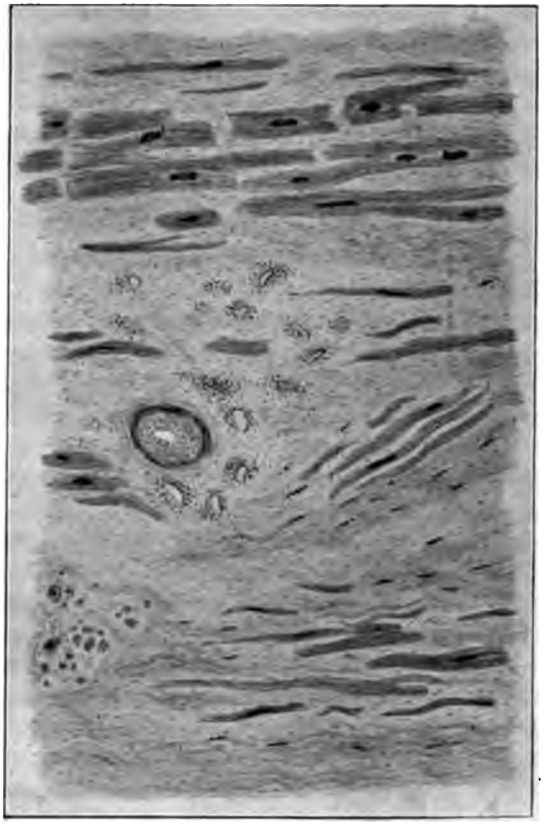


Fig. 297.—Fibrous transformation of heart. The muscular tissue is in great pa replaced by fibrous tissue. × 50.

heart, leading up, it may be, to death more or less suddenly. **A** **pectoris** is a frequent feature in the cases of considerable interf with the circulation.

Literature.—Cohnheim, Virch. Arch., lxxxv., 503, 1881; Wickham Le cardiac aneurysms, Bradshaw lect., 1884; West, Path. Trans., xxxv., 110 Quain, On fatty heart, 1851; Weigert, Virch. Arch., lxxix., 1880; Huber lxxxix., 1882; Turner, Trans. Med. Congress, London 1881, i., 427; Robin

Hebd., 1885, No. 51; PAUL, ibid., No. 10; ZIEGLER, Lehrbuch, and Deutsch. Arch. f. klin. Med., xxv.; HILTON FAGGE, Medicine, ii., 32; STEVEN (with full literature), Lancet, Dec., 1887, Jour. of Path., ii., 190, 1893, and Glasgow Hospital Reports, vol. i., 1898; LAZARUS-BARLOW (Dissecting aneurysm of heart), Brit. Med. Journ., ii., 1899.

IV.—RETROGRADE CHANGES IN THE HEART.

1. **Atrophy of the heart.—Brown atrophy.**—This condition is one of comparatively frequent occurrence, but is for the most part merely a part of general atrophy or emaciation of the body. In emaciating diseases where the muscular system as a whole has undergone great reduction in bulk, the heart is found to take part in the same process. Taking the normal weight of the heart as 9 ounces for the female, and 10 or 11 ounces for the male, we may find it reduced to 6 or even 5 ounces. Viewed as a whole the heart is obviously smaller, and it has a darker colour than normal, while the coronary arteries stand out unduly, often as somewhat prominent tubes. This change of colour and the prominence of the arteries are largely due to the loss of the sub-pericardial fat, which normally covers the greater part of the surface and accompanies the coronary arteries, partially embedding them in the adipose tissue.

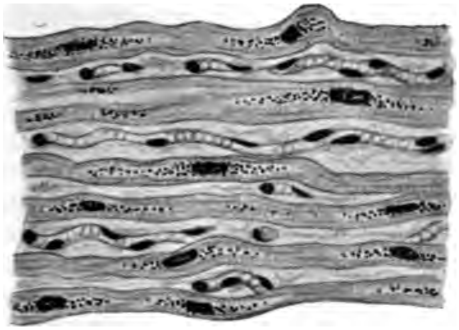


Fig. 298.—Brown atrophy of heart. × 300.

The muscular substance when incised is found to be deeper in colour and tougher than usual. On account of this the name of **Brown atrophy** is given. With the atrophy of the muscular fibres there is a concentration of pigment granules around the nuclei (Fig 298). In nearly all old persons there is at the two poles of each nucleus a group of brown pigment granules, and these increase greatly. There is also frequently a distinct demarcation of the cells which constitute the muscular cylinders, an appearance which is not normally present. This has, without sufficient grounds, been interpreted as an indication of disintegration of the muscle. Brown atrophy may be associated with fatty degeneration, the brown pigment being distinguishable by its colour from the fat granules.

2. **Fatty infiltration of the heart.**—The normal heart is well known to present on its surface a certain amount of adipose tissue (see Fig. 299). This fat is beneath the pericardium, lying between it and the muscular substance of the wall. It is normally most abundant along the course of the coronary arteries, along the inferior border of the right ventricle, at the apex, and at the origins of the great vessels. In different individuals the amount of the adipose tissue and the extent to which it covers the muscular substance so as to conceal it from view, vary greatly, but it may be said generally that a considerable part of the surface of the right ventricle and the greater part of the left are usually free of fat. Sometimes this fat increases greatly, both in superficial area and in thickness, so that the entire right ventricle may be covered while a portion of the left is still free, or the whole heart may be coated with a thick mantle of fat (see Fig. 301).

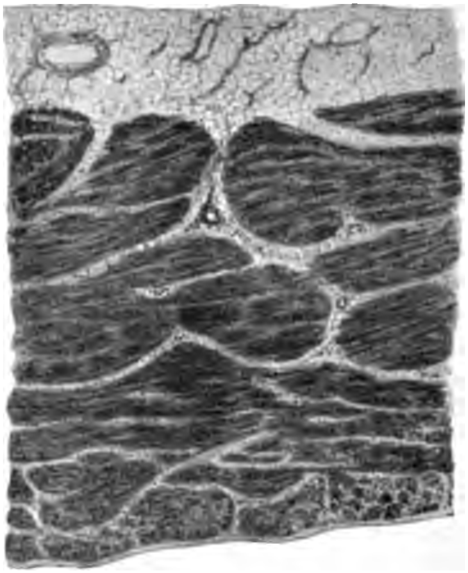


Fig. 299.—Wall of heart showing normal condition of adipose tissue on surface, to contrast with next figure. × 10.

The adipose tissue does not always confine itself to the pericardium, but frequently extends into the connective tissue lying between the muscular fasciculi in the proper muscular wall of the heart. The superficial layers of the muscular wall may thus be largely replaced by adipose tissue, which may even appear in isolated patches immediately beneath the endocardium (see Fig. 301). It is not uncommon to find the proper muscular substance of the right ventricle largely replaced by adipose tissue, only a thin layer of red muscle appearing inside the thick layer of fat, and even this is interrupted by areas of adipose tissue. Figure 300 shows an extreme degree of fatty infiltration. It is from a section of the right ventricle the muscle of which is dissociated and encroached upon by adipose tissue which extends even to the internal surface under the endocardium. Of course, in such cases, there is great loss of the muscular power of the heart, the right ventricle being more affected than the left.

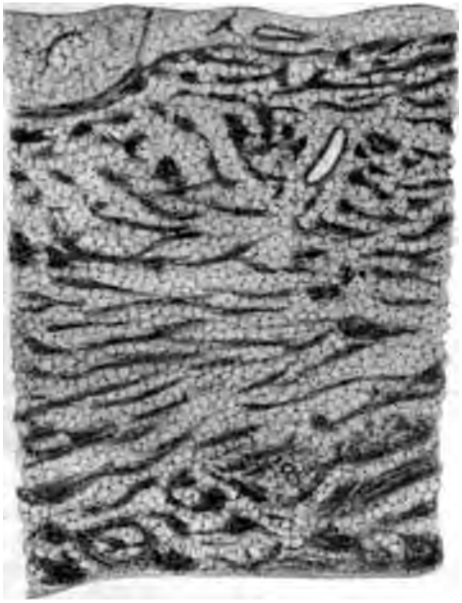


Fig. 300.—Fatty infiltration of heart. The illustration shows the whole thickness of the right ventricle. Adipose tissue extends amongst the muscle through the entire thickness of the wall. × 10.

In some cases the increase of the external fat is merely part of a general obesity, in which the fat in all its various localities throughout the body takes part. But sometimes its significance is much more serious, and this applies especially to the cases in which adipose tissue forms between the muscular bundles. The space occupied by the fat must be obtained at the expense of the proper muscular substance, and the question arises whether the atrophy of the muscle is the primary condition or the fatty infiltration. We have to take into consideration the fact that a fatty infiltration of an exactly similar character occurs, as we have already seen, in voluntary muscle, and is there associated with disuse of the muscle. In this case the loss of function is the primary condition and the fatty infiltration is secondary. And so in the case of the heart, we meet with fatty infiltration in cases where there is no general obesity, often in old debilitated persons, or even in those who have been subject to some emaciating disease such as cancer. In that case we may infer that the atrophy and weakening of the muscle have been primary and the infiltration of fat secondary.

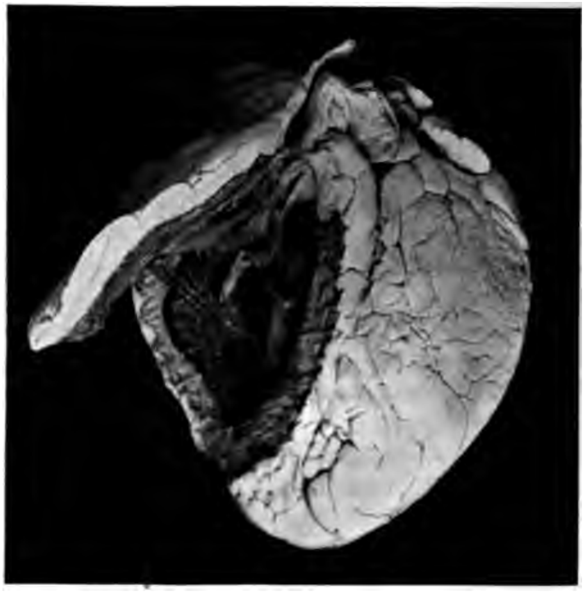


Fig. 301. Fatty infiltration of the heart.

3. **Fatty degeneration of the muscular substance.**—This condition is of exceedingly frequent occurrence in the heart, especially in its minor degrees. Any disease which causes a serious deterioration of the blood may produce it, and it is seen in its most pronounced form in the various kinds of anæmia, in leukæmia, and in the acute fevers. It is also brought about in a very pronounced form in poisoning by phosphorus. In a minor degree it is seen in debilitating diseases, and is often the more immediate cause of death in hypertrophy of the heart.

The fatty degeneration usually shows itself in patches, so that the muscular tissue is seen to be, as it were, flecked with pale spots or streaks. This is best seen on examining the muscular tissue from within (see Figs. 302 and 303), as the endocardium generally produces but little obscuration of these markings, and they are most abundant in the inner layers of the muscular substance. This flecked appearance is not always present, and it would be a mistake to infer the absence of fatty degeneration from its absence. The heart again is generally flabby, friable, and pale in colour, but a very flabby heart may be very

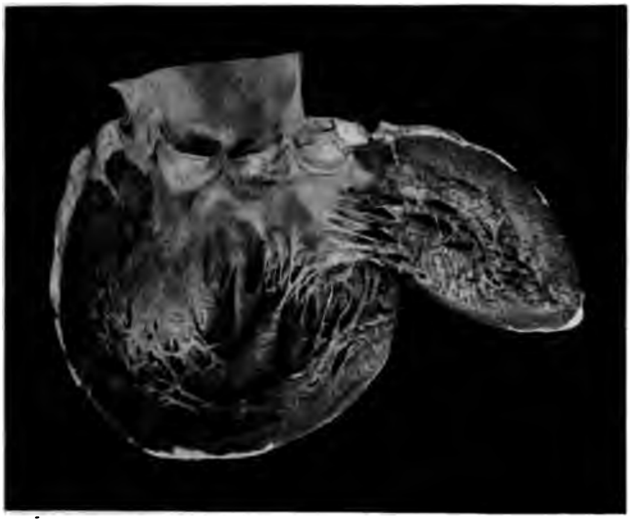


Fig. 302. Fatty degeneration of the heart.

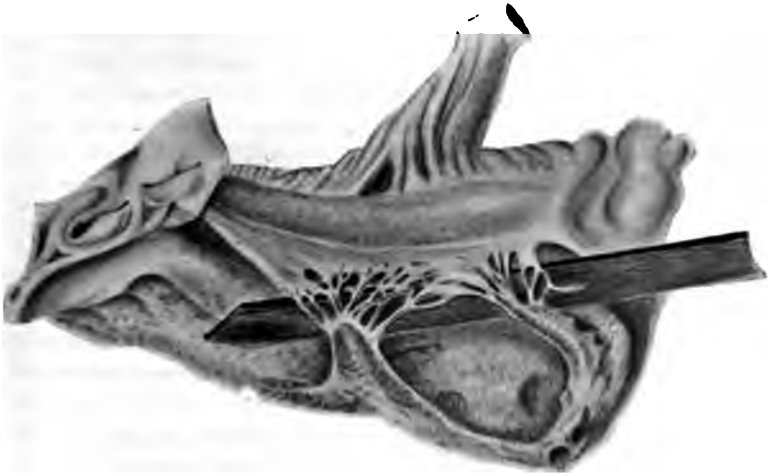


Fig. 303.—Fatty degeneration of the muscle of the right ventricle and auricle.

little fatty, and fatty degeneration may co-exist with a comparatively firm muscular tissue. Microscopic examination should therefore alway be resorted to.

Under the microscope in those cases in which the degeneration is i patches, the transparent muscula tissue is seen with a low powe to be interrupted by opaqu patches, as in Fig. 304. Th general outline of the muscul cylinders is preserved, but th are evidently replaced by som foreign material. Under a hig power, as in Fig. 305, the indiv dual fat drops become apparent These fat granules are frequently seen to be in rows, representing the original muscular fibrillæ, and the contractile substance is obviously lost or converted into oil. In minor degrees the degeneration is, as a rule, more uniformly distributed in the muscula substance, and we can see that the fat granules generally appear firs in the neighbourhood of the nuclei of the muscular fibres, formin elongated collections extending from either pole of the nucleus.

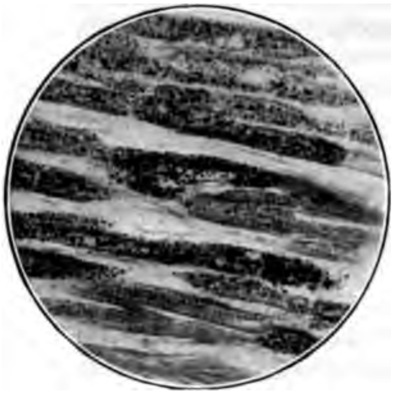


Fig. 304.—Fatty degeneration of the heart. The occurrence of the lesion in patches is indicated by the dark appearance of the fibres. × 90.

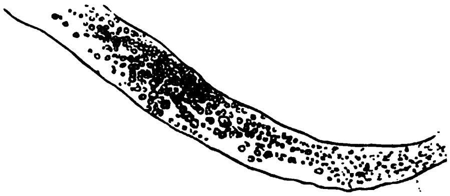


Fig. 305.—Fatty degeneration of the heart. A single fib with oil drops in it, as seen in the fresh state. × 350.

4. **Fatty degeneration of the endocardium.**—The valves of the heart, more particularly the mitral, frequently show opaque white or yellow patches with little or no thickening. These are areas of fatty degeneration they occur mostly in debilitated and anæmic persons, but are als met with in cases where otherwise the body is well nourishe These opaque patches without thickening should be carefully di tinguished from the results of chronic endocarditis, which are of muc more serious import.

5. **Calcareous deposition in the pericardium and connective tissu** —In connection with pericarditis it is not very uncommon to mee with calcareous infiltration of old fibrine or dried-in pus which ma remain on the surface. Again, where, in the pericardium, there ha

been great new-formation of dense connective tissue from prolonged pericarditis, lime salts may be deposited in the hard tissue. In this way we may have the heart almost enclosed in a firm shell. But, further, in the muscular substance, old cicatrices may calcify, or an abscess may dry-in and become impregnated with lime salts. In this way we may have stony masses developed in the muscular wall, these being actually in the connective tissue of the wall. Of much greater frequency and importance is the deposition of lime salts in the valvular structures. This is usually a result of the changes occurring in chronic endocarditis (which see), but we meet with considerable calcification, especially in old persons, without much thickening.

6. **Calcareous infiltration of the muscular substance.**—The author has met with two cases of calcareous infiltration of the muscular substance of the heart, but they differed somewhat from each other. In one the lime salts were deposited in massive form, converting the muscular fibres into solid cylinders, while in the other there was a fine granular deposition, causing the fibres to resemble those in fatty degeneration.

In the one there were pale patches seen with the naked eye in the muscular substance, somewhat like those of fatty degeneration, but larger and situated in the superficial layers just under the pericardium. These patches had, even to the naked eye, a streaked appearance, the streaks following the direction of the muscular fibres and indicating that the condition affected the muscular substance. On cutting into the patches a gritty feeling was experienced, and under the microscope the appearances seen in Fig. 306, were visible. The muscular fibres were converted into solid cylinders which had a markedly crystalline appearance. Many of the cylinders were fractured transversely. On adding hydrochloric acid to these patches, there was an abundant evolution of gas and a solution of the lime salts. After the lime salts were dissolved the muscular fibres were restored so far as their outline was concerned, but their transverse striæ were gone. The case in which this occurred was one of pyæmia, and it is probable that the arteries in connection with these patches had been obstructed, causing a necrosis of the portion of tissue which subsequently became impregnated with lime salts.

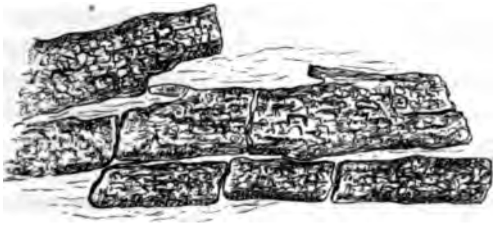


Fig. 306.—Calcareous infiltration of the muscular tissue of the heart. The branching muscular cylinders are shown in a petrified condition with transverse fractures. From a case of pyæmia. × 350.

In the other case the condition was very different. A certain portion of the muscular substance of the left ventricle was found of a pale colour suggesting fatty degeneration, but the colour was continuous, and it was the external layers that were affected, and that mainly towards the apex. On microscopic examination the muscular fibres were found clouded with fine granules not unlike fat granules (Fig. 307). The granules, however, were dissolved by hydrochloric acid, but without evolution of gas. Köster has met with a somewhat similar case, and he believes that the salt here is, in part at least, sulphate of lime. In this case the true pathology of the condition was obscure.

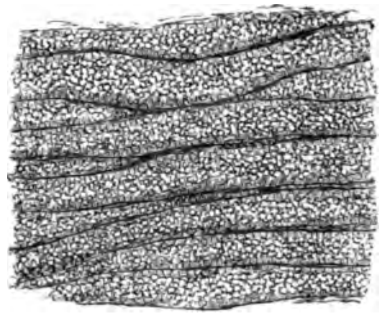


Fig. 307.—Calcareous infiltration of the muscular fibre of the heart. Fine granules occupy the muscular fibres. × 300.

7. Other forms of degeneration.—Amyloid degeneration affecting the intermuscular vessels is not uncommon. In extreme cases the endocardium may be involved. **Hyaline degeneration** occurs in the muscular cylinders in sudden obstruction of a coronary artery (see p. 491). **Mucous degeneration** is sometimes seen in the valvular structures in the form of thickenings of the marginal parts of the curtains.

It is not uncommon to find the muscle fibres of the heart separated one from another as if from some alteration in the cement substance (*Segmentation*). In a number of conditions the fibres may be found broken across (*Fragmentation*). The precise significance of these conditions is not known.

8. Injuries and rupture of the heart.—Wounds of the heart are not by any means necessarily fatal, although, of course, commonly so (see Fig. 308). In most cases of penetrating wound of the heart there will be fatal hæmorrhage, but such wounds, especially if they do not divide the muscular fibres transversely, may heal, and be finally closed by connective tissue. There are even cases in which the point of a knife or a bullet has lodged in the heart and become surrounded by a connective tissue capsule.

Spontaneous rupture of the heart rarely occurs except in consequence of softening from obstruction of a coronary artery, as has been already described. It sometimes occurs in pyæmia from the formation of an abscess in the wall of the heart. It may also result from the bursting of an aneurysm of the heart, but this also is the more remote result of disease of the coronary arteries. Rupture of the heart is sometimes ascribed to fatty degeneration of the muscular fibre, but there seems no evidence that this alone can cause it. The rupture mostly occurs in the left ventricle, and near the apex or towards the aortic orifice. There is usually a large escape of blood into the sac of the pericardium, and the patient dies rapidly. Beadles has drawn special attention to the occurrence of spontaneous rupture of the heart in the insane.

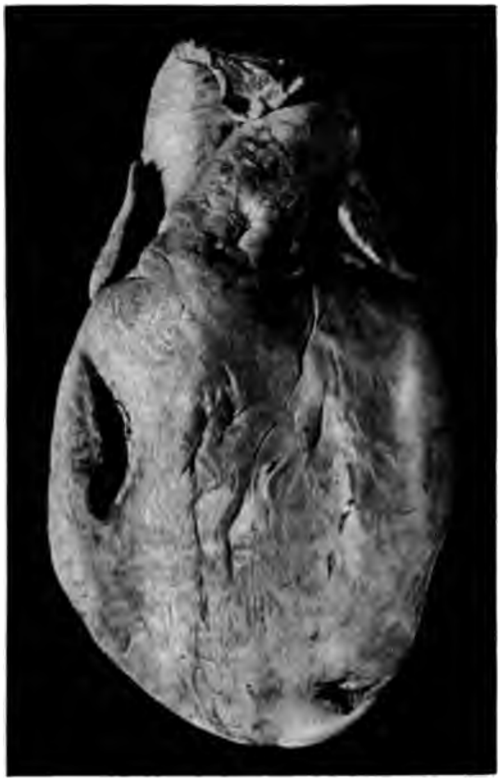


Fig. 388.—Bullet wound of heart. The aperture of entrance and exit are shown.

Post-mortem rupture of the heart is occasionally seen as the result of putrefactive changes. It is most common in the right ventricle.

Literature.—*Atrophy and fatty changes*—ALBERS, Atrophie des Herzens; in Casper's Wochenschr., 1836, 50; CHURCH (small heart weighing 3 oz. 1 dr.), Path. Trans., xix., 1868, p. 147; R. QUAIN, Fatty dis. of heart, 1851; BARLOW, Fatty legen., 1858; PERL (Fatty heart in anæmia), Virch. Arch., lix. 39; also PONFICK, Berl. klin. Wochenschr., 1872. *Calcification*—COATS, Glas. Med. Jour., Aug. 1872; lso HESCHL, Zeitschr. f. pract. Heilk., 1860, and ROTH, Correspbl. f. schweizer erzte, 1884; ROBIN et JUHEL-RENOY, Arch. gén. de méd., 1885; ALLAN BURNS exaggerated case of calcification of pericardium and heart), Dis. of heart, etc., 1809. *myloid degeneration*—HESCHL, Wien. med. Wochenschr., 1870; KYBER, Virch. rch., lxxxi.; WILD, Amyl. und hyalin degen. des Bindegewebes, 1885. *Segmentaion and Fragmentation*—HEKTOEN, Amer. Jour. Med. Sciences, 1897; MACCALLUM, Jour. Exp. Med., 1899. *Rupture*—see Schrötter, in Ziemssen's Encycl., vol. vi. Various cases in Path. Trans., etc.; HADDON (Rupture in pyæmia), Path. Trans., xxxv., 121; ROBIN, Gaz. hebd., 1885, No. 51; BEADLES (Rupture in the insane), Path. Trans., xlvi., p. 36.

V.—HYPERTROPHY AND DILATATION OF THE HEART.

Hypertrophy and dilatation concern chiefly the muscular substance of the heart, giving rise according to circumstances to enlargement of particular ventricles or auricles, or of the heart as a whole.

Causation.—It will be found that this new-formation of muscular tissue is in nearly all cases **Compensatory**, that is, intended to make up for some defect in the heart itself or in the circulation. The needs of the organism assert themselves by the nervous connections of the body on the cardiac ganglia, and the contractions become more forcible. Within the limits of health, and without any increase in the volume of the cardiac muscles, there are great variations possible in the force of the cardiac contractions. But where the heart is for a long period impelled to unusually violent exertion, it becomes hypertrophied.

In many of these conditions there is a mechanical interference with the flow of the blood either in the heart itself or in the arteries, and as a consequence the heart is overloaded with blood, but in some the mechanical cause is not very obvious. As a general rule the cavities are dilated, and the **dilatation** may indeed be the primary condition, the hypertrophy occurring as a secondary consequence. It is usual, therefore to consider dilatation and hypertrophy together, there being commonly some dilatation along with the hypertrophy.

Hypertrophy from overstrain. Idiopathic hypertrophy.—Pathologists have frequently observed that hypertrophy of the heart has existed without any mechanical hindrance in the circulation being discoverable. Some of these cases have been traced to functional disorders of the heart, the organ contracting more frequently and violently than it should. But some cases are really due to frequent and violent exercise, which has been so prolonged as to have taxed the contractile power of the heart beyond its normal ability. The acute overstrain may be produced by prolonged muscular exertion, such as in hill-climbing (Allbutt), athletic exercises, etc. It has been induced experimentally by Roy and Adami, by narrowing the aorta. In that case dilatation of the heart, followed by incompetence of the auriculo-ventricular valve, was the result.

When frequently repeated, such overstrain will lead to hypertrophy, which may only partly compensate, and there may be a permanent over-dilatation with incompetence of the valves

This has been observed under a variety of circumstances. It has been described as occurring amongst the Cornish miners, who after their work was over had to reach the surface of the earth by climbing ladders for an hour (Peacock), or in the case of people in hilly countries who are in the habit of carrying loads uphill (Münzinger). It has been observed also in young soldiers, who, as a result of severe drill, have frequently attacks of palpitation. The ability of the heart varies greatly in different individuals; in some the strain of drill reveals a weakness which has come to be recognized in the army as "irritable heart" (Da Costa, Maclean and Myers). During campaigns, also, long marches may so overstrain the heart as to lead to dilatation and hypertrophy (Fräntzel).

Adhesion of the pericardium and **Valvular disease** are familiar causes of hypertrophy. In both of them interference with the circulation exists, as will be seen further on.

Obstruction of the coronary arteries, leading to permanent loss of a portion of the muscular wall, will cause hypertrophy, both on account of the loss of tissue and of the derangement of the muscular apparatus of the wall.

Hypertrophy is a frequent result of **Obstruction to the circulation in the lungs.** In emphysema, for instance, there is great obliteration in the pulmonary vessels, and the right ventricle contracts more vigorously to compensate. A similar result may follow other chronic diseases of the lungs, and even extensive pleural adhesions.

Interferences with the systemic circulation, especially **Aneurysms and Rigidity of the arteries**, are frequent causes of hypertrophy of the left ventricle.

Chronic Bright's disease leads to hypertrophy of the left ventricle by raising the general systemic blood-pressure. (See further under Diseases of the Kidneys.)

Forms of cardiac hypertrophy.—From what has gone before, it will be apparent that hypertrophies of the heart vary greatly in amount and in the distribution of the enlargement. The term **General hypertrophy** is used to express an enlargement of the heart in all its parts, while **Partial hypertrophy** expresses an enlargement limited to a part of the organ. As it is the ventricles which are specially exposed to the causes of hypertrophy, the partial forms are divisible into two, namely, hypertrophy of the right and left ventricles respectively.

In **General hypertrophy** the general shape of the heart is not much altered. The heart is enlarged in all its parts, the ventricles and auricles are increased in capacity, and their walls thickened. The heart is like that of a bullock in size, so that the name *cor bovis* is often applied to it.

When the **right ventricle** is mainly affected, the heart assumes a quadrilateral form (see Fig. 309). On examining the eart as it lies on its posterior surface, after removal from , the right ventricle is seen to occupy the greater part of rior aspect. The normal position of the septum, as shown companying figure, is slightly to the right of the left border, reaches the apex region slightly to the right of the true In the heart the position of the septum is always indicated surface by a coronary artery, which, with its padding of fat, ies a groove corresponding with the anterior border of the m. In hypertrophy of the right ventricle, as shown by the d line in the figure, the apex is unduly obtuse, and it is ofte ifficult to determine what is its exact seat. The septum is nearer he left border than usual, and it reaches the apex region rather to he left than the right of the most projecting point. The right entricle also monopolizes the anterior aspect of the heart still ore than in the normal condition. When the heart is laid open, he undue thickness of the right ventricle, as well as the en-argement of its cavity, become apparent. Fig. 311 shows the ppearances on section.

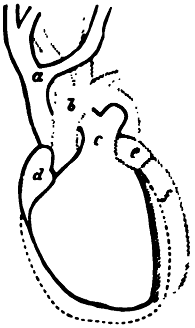


Fig. 309. Hypertrophy of right ventricle. The alteration in shape is indicated by the dotted line; *a*, superior vena cava; *b*, aorta; *c*, conus arteriosus; *d*, right auricle; *e*, left auricle; *f*, left ventricle. (Rindfleisch.)

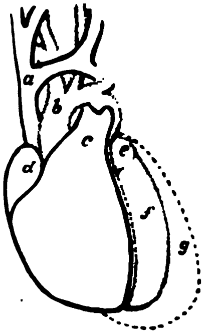


Fig. 310.—Hypertrophy of left ventricle. The alteration in shape indicated by dotted lines; *g*, the hypertrophied ventricle. (Rindfleisch.)

In **Hypertrophy of the left ventricle** the relations are very ifferent, as shown in Fig. 310. The heart as a whole is mor longated and pointed than normal, and this is often very strikin he apex part especially appears greatly prolonged. When the hea viewed on its anterior aspect the septum is seen to lie more he right than is normal, and the true apex is much further to eft of the point at which the septum reaches the apex region. aying open the heart, the thickening of the wall of the left vent s very obvious, and the septum is often greatly thickened. The eptum belongs partly to the left and partly to the right ventricle, ut as the left ventricle is much thicker than the right, the septum longs more to the left. It will partake in the hypertrophy of ther ventricle, and, in the case we are considering, the thickening often very striking. The thickened septum frequently bulges into

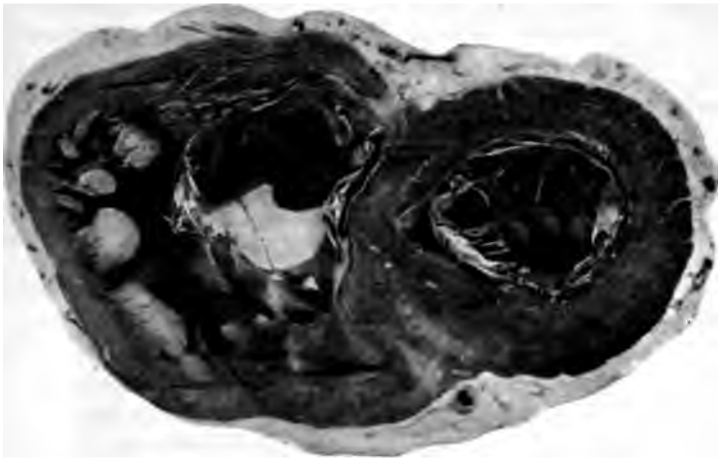


Fig. 311. Hypertrophy and dilatation of the right ventricle of the heart.

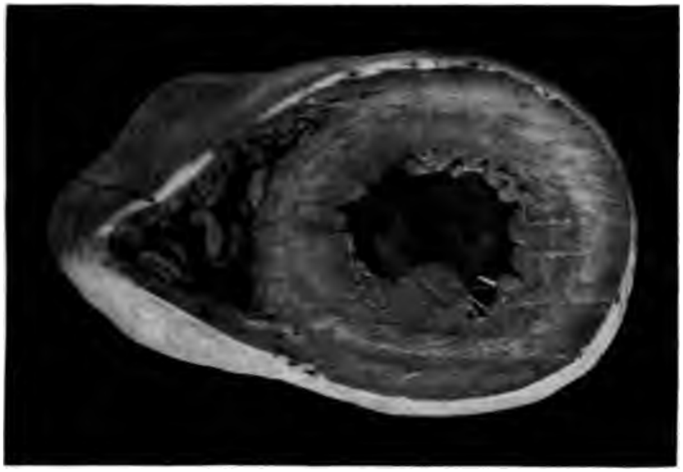


Fig. 312.—Transverse section of ventricles of heart showing hypertrophy of the left, from a case of chronic Bright's disease.

the right ventricle, sometimes diminishing its capacity greatly, and even producing actual obstruction of the conus arteriosus. In transverse section the hypertrophy of the left ventricle is sometimes very manifest, the right forming merely a crescentic appendage (see Fig. 312).

Hypertrophy and dilatation of the auricles is less common, but may be very marked. The right auricle is specially liable to dilatation, in consequence of mitral or tricuspid stenosis (see Fig. 313), or obstruction to the pulmonary circulation. This dilatation may reach an extraordinary amount, as in Fig. 313, and in a case recorded by Middleton. Dilatation of the left auricle is less frequent. It occurs by no means regularly as a result of mitral stenosis, but occasionally does so. Owen and Fenton record a striking example of excessive dilatation of the left auricle.

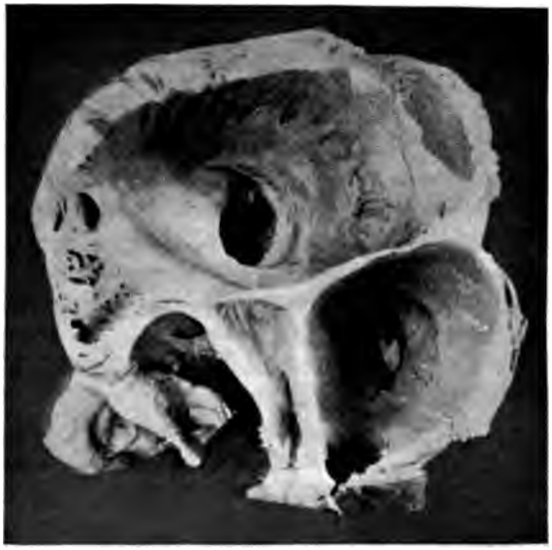


Fig. 313. -Great dilatation of right auricle. Stenosis of mitral and tricuspid orifices. The auricles are shown in transverse section, the right above much dilated. The contracted orifices are also shown.

The total **Increase in weight** in hypertrophy of the heart is greatest in cases where both ventricles are enlarged, and the weight of the heart in such cases not uncommonly reaches from 27 to 30 ounces. It is least where the right ventricle alone is enlarged, because this ventricle, as a whole, weighs much less than the left, but in pure right ventricular hypertrophy a weight up to 17 ounces is not infrequent. In hypertrophy of the left ventricle, as in Bright's disease, the weight is frequently over 20 ounces.

The hypertrophied heart often presents a peculiarly firm condition of its wall, and this has been ascribed by Sir William Jenner to a **Passive congestion of the heart**. Cases of cardiac hypertrophy are very frequently such as to lead to a general venous engorgement, in which the heart itself, being related to the general venous system, partakes. Now, prolonged venous hyperæmia produces in organs, as we have seen already, a certain hypertrophy and increased density of the connective tissue. Some part of the hypertrophy in such cases may even be due to increase of the interstitial connective tissue. Hence the result is that the walls of the heart are more rigid than normal, and when the cavities are laid open they do not collapse, but stand out with their outline retained, the walls having a tough leathery character. The muscular substance also is frequently of a very red colour, this being largely due to the excess of blood in the vessels.

Literature.—GAIRDNER (causes of dilatation), Brit. and For. Med. Chir. Review, 1853; PEACOCK, On some of the causes and effects of valv. dis. of heart, 1865; LEITZ, Deutsch. Arch. f. klin. Med., xi. and xii.; MÜNZINGER, ibid., xix.; MACLEAN, Brit. Med. Journ., Feb. 16, 1867, etc.; MYERS, On diseases of the heart among soldiers, 1870; FRAENTZEL, Virchow's Arch., lvii., 215; CLIFFORD ALLBUTT, St. George's Hosp. Rep., 1870, v., 23, and System of medicine, 1898, vol. v.; DA COSTA, Am. Journ. of Med. Sc., 1871; ROY and ADAMI, Brit. Med. Jour., 1888, ii., 1321; LAACHE (Athletics), Internat. Med. Congress, 1894, Brit. Med. Jour., 1894, i., 738; JENNER (Congested heart), Med. Chir. Trans., 1860, p. 199; MIDDLETON, Clinical Records, 1894; OWEN and FENTON, Clin. Soc. Trans., xxxiv., 1901.

VI.—INFLAMMATIONS OF THE HEART.

The inflammations of the heart are divisible into three forms, according as the myocardium, the endocardium, or the pericardium is the primary seat. As the myocardium is closely in contact with the pericardium and endocardium, it will sometimes partake in their inflammations.

1. **Myocarditis.**—This name designates inflammation of the muscular substance of the heart. Several forms are distinguished.

Parenchymatous myocarditis is a general inflammation of the proper muscular fibre of the heart. The term is applied chiefly to cases of aggravated parenchymatous degeneration, occurring in acute infective diseases. It is met with chiefly in septic and pyæmic conditions, and in diphtheria, typhoid fever, gonorrhœa, etc.

It must be said that this form of disease is somewhat indefinite, and, in any case, is secondary in its origin. There is reason to believe, however, that certain of the morbid poisons attack the heart more especially, and act directly on its muscular substance. This is true especially of diphtheria, and perhaps also of small-pox.

Purulent myocarditis is also a secondary affection, occurring in consequence of the transportation of material containing infective microbes. It is frequently embolic, being part of the phenomena of **Pyæmia** or **Ulcerative endocarditis**. The infective matter is distributed by the coronary arteries, and gives rise to multiple softenings going on to the formation of **Abscesses.** Such localized suppurations soften the wall of the heart, and may lead to **Aneurysm** or **Rupture.** The abscesses do not readily burst into the cavities of the heart, but are liable to extend to the pericardium, where they give rise to a purulent pericarditis. A suppurative inflammation of the myocardium may also occur by extension from the endocardium in ulcerative endocarditis. The microbes on which this disease depends may propagate into the muscular substance, and so cause ulceration (*acute ulcer of the heart*), or may even lead to an abscess burrowing in the wall of the heart. This again may lead to aneurysm or rupture of the wall. It is seldom that such abscesses as these heal, but there are cases of pyæmia in which calcification either of the abscesses, or of portions of the heart's substance which had been softened by embolism, has been observed. A case investigated by the author, and referred to under calcareous infiltration, was probably of this kind.

Interstitial myocarditis consists in an inflammatory increase of the interstitial connective tissue. There is no doubt that in the great majority of cases the cicatricial or tendinous patches met with in the heart are due to obstruction of the coronary artery, as already described, and in all such cases these arteries should be examined. A more direct local inflammation may be due to other specific causes. Thus in pericarditis or in endocarditis, the inflammation may extend to the muscular substance, causing induration of the superficial layers on the one hand, or of the internal layers on the other. And again in chronic endocarditis affecting the mitral valve we often find, along with thickening of the chordæ tendineæ, a partial conversion of the musculi papillares into dense fibrous tissue, in fact, an interstitial inflammation with destruction of the muscular tissue.

A localized interstitial myocarditis may be the result of **Syphilis.** There is sometimes a definite gumma, around which a great new formation of connective tissue has occurred, but there may be a local cicatricial condition without any gumma being detected. In these cases there has probably been a gumma at an earlier period. (See further on.) Syphilis may also produce fibrous transformation by causing syphilitic lesions in the coronary artery such as have been already described (see Fig. 294, page 492).

It is doubtful whether a general interstitial myocarditis occurs. Some have asserted its existence in dilated and hypertrophied hearts, and especially in the hypertrophy of the left ventricle in Bright's disease (see especially Turner). There is, no doubt, in the congested heart hypertrophy of the connective tissue, but the author has failed to find evidence of a true inflammatory condition either here or in the hypertrophy of Bright's disease.

2. **Endocarditis.**—The various forms of endocarditis are somewhat closely related to each other, but it is possible to distinguish three forms—a simple acute, a simple chronic, and an ulcerative or infective form. The acute forms are simply more or less marked examples of the same process. They are considered separately for purposes of convenience.

(*a*) **Simple acute endocarditis** (*Endocarditis verrucosa*) occurs as a secondary effect of certain acute febrile diseases.

Causation.—Chief amongst the causes is **Acute rheumatism**, but **Chorea** is also to be assigned as a frequent cause, and more rarely scarlet fever, measles, typhoid fever. According to Bamberger 20 per cent. of the cases of acute rheumatism are complicated with acute endocarditis, and according to Osler 30 per cent. of the cases of chorea are so affected. Whatever view we take of the origin and nature of acute articular rheumatism, it must be admitted that the blood is of an unusually irritating nature, being the carrier of some irritant of unknown nature (see p. 166). The occurrence of acute inflammations in several joints often removed considerably from one another, and the frequent supervention of inflammation in the pericardium and endocardium, are sufficient evidences of this. The irritant, whatever be its nature, seems to act specially on connective tissue membranes, and on such as are **exposed to friction** of their surfaces. It affects the joints where the synovial membranes lie against each other and in the movements of the joints are moved on one another. It attacks the pericardium where the movements of the heart cause continuous rubbing, and when it attacks the endocardium it affects exactly the localities where the surfaces come into contact. It is as if in addition to the irritant in the blood, the mechanical irritation of friction were necessary to the occurrence of inflammation, and it may be added that in the adult the inflammation is usually limited to the valves of the left side of the heart, where the higher tension of the blood and greater force of the heart make the mechanical force of friction greater than on the right side. We shall see afterwards how this fact bears on the localization of the endocarditis.

Characters of lesion.—The most characteristic effects produced in acute endocarditis are the so-called **Warty vegetations**, which are pale, irregular projections from the surface of the endocardium, generally of small size and somewhat shaggy in appearance. (See Figs. 314 and 315.)

The vegetations are composed partly of the swollen, inflamed tissue of the valve and partly of fibrine deposited on the inflamed surface. The inflamed connective tissue produces round cells and is converted into granulation tissue, and the affected parts are thus increased in bulk, and rendered more friable so that irregular projections are produced. The projections are enlarged by deposition of fibrine, which may be regarded as a kind of fibrinous exudation, but is derived from the blood flowing over the surface, and not from the vessels of the part. It is, perhaps, more correctly a thrombosis, and as the blood is in motion the **White thrombus** is the form produced. The fibrine generally forms the greater part of the bulk of the vegetations (see Fig. 316). On their first occurrence the vegetations are limited to the parts of the valves which come against each other during their closure, and this localization continues more or less throughout.

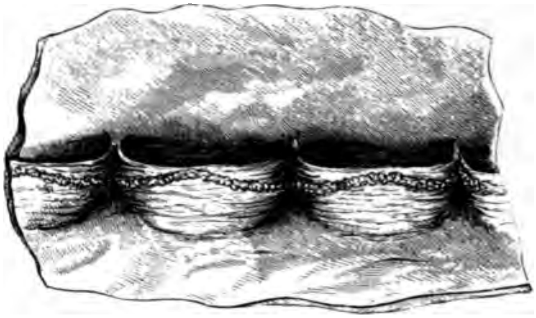


Fig. 314.—The aortic valve in acute endocarditis. The warty vegetations, occupying the lines of contact, are shown.

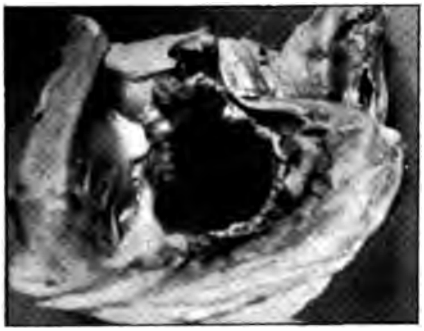


Fig. 315.- Acute endocarditis of mitral valve. The curtains are fringed with prominent warty vegetations. From a child of seven, the subject of acute rheumatism.

When, after removal of the heart, a stream of water is sent into the aorta cut transversely a short distance above the valve, we can look down on the valve closed by the force of the water. It will then be seen that, in the normal valve, the curtains are not in contact by their margins, but that the line of contact is slightly removed from their edges, and a certain portion of the valve floats free in the water, taking no direct part in the closure of the orifice. The line of contact is nearest the edge of the curtain in the middle of each segment, *i.e.* at the corpus Arantii, and forms on either side of this a curved line with the convexity downwards. Between the line of contact and the edge of the curtain the valve is often perforated, and it may even, as we have seen before (p. 483, Fig. 287), be partially resolved into tendinous cords without interfering with the closure of the valve.

In the mitral valve the line of contact is also removed from the edges of the curtains. In the case of the aortic valve the line of contact is of course on the ventricular side of the curtains, but in the mitral it is on the auricular side, and in order to see the vegetations in acute endocarditis it is usually necessary to examine the orifice by looking in from the auricle. Acute endocarditis of the mitral valve often escapes notice from this not being done.

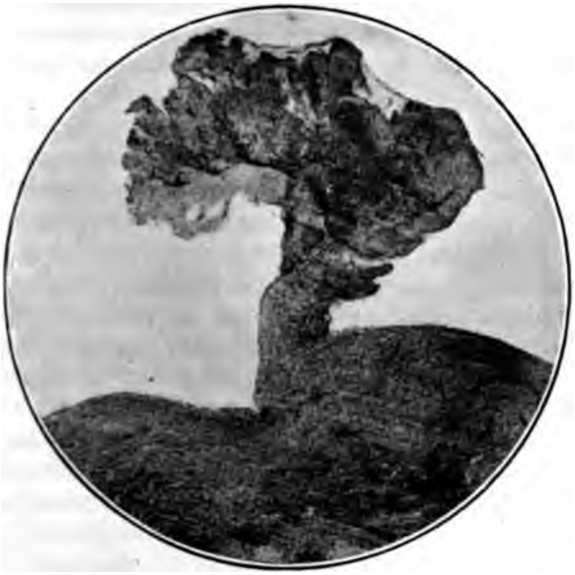


Fig. 316.—Acute endocarditis from a vegetation on the mitral valve. × 20.

In acute endocarditis the warty vegetations frequently demarcate very accurately the lines of contact of the aortic and mitral valves, and the appearances produced in the former case are indicated in Fig. 314. When the inflammation extends to the valves of the right side, the same principles apply. In the case of the pulmonic valve the vegetations appear along the line of contact on the ventricular aspect of the curtains, and in the tricuspid valve they are to be seen by looking down through the auricle.

The occurrence of these changes in the tissue renders it **unduly brittle**, and it is not surprising to find that portions of the vegetations

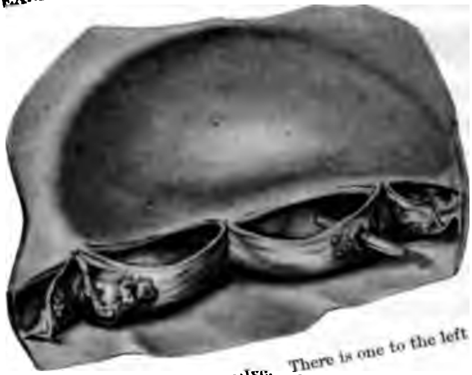
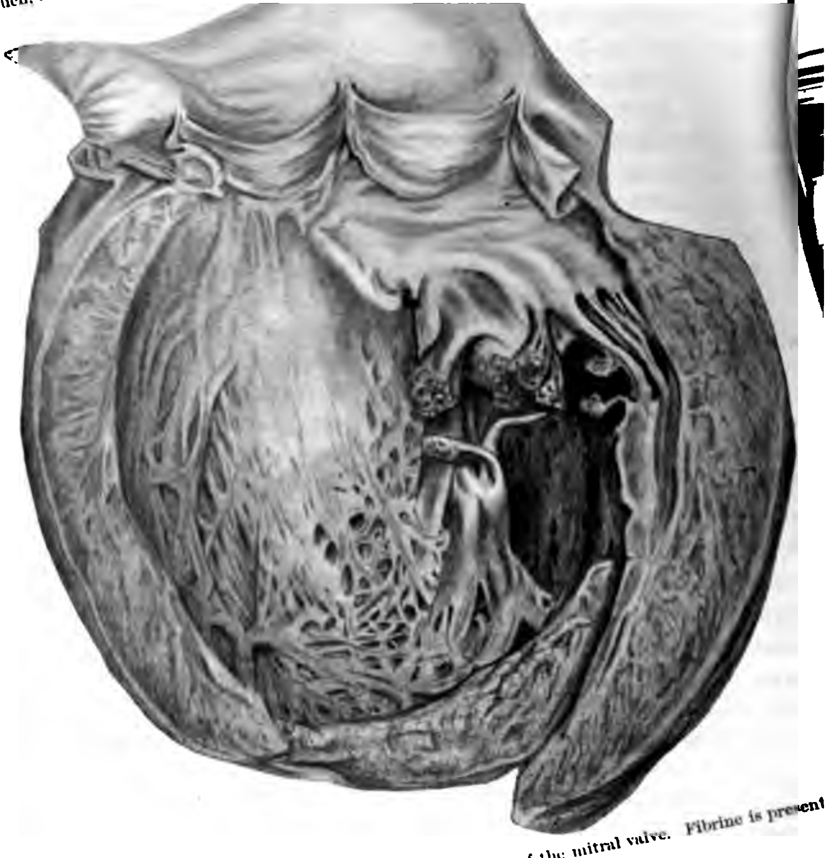


Fig. 317.—Aneurysms of the aortic valve. There is one to the left in the form of a pouch, and one to the right which has ruptured.



Rupture of the chordæ tendineæ of the mitral valve. Fibrine is present are frequently broken off and carried by the arteries to distant parts, to produce embolism there. These broken-off pieces are mostly small, and, beyond the ordinary phenomena of embolism in small arteries and capillaries, they do not by their own nature produce much disturbance, in this respect contrasting with the emboli of ulcerative endocarditis. The softening of the tissue may result in one of two further lesions, either of which may interfere with the function of the valve: these are rupture of the chordæ tendineæ and valvular aneurysm.

Rupture of the chordæ tendineæ sometimes occurs in the mitral valve both in acute and ulcerative endocarditis when the inflammation happens to extend to these structures (see Fig. 318). The result will be that during the systole of the ventricles the valvular curtain will be allowed to some extent to pass upwards towards the auricle, and so allow of regurgitation through the orifice.

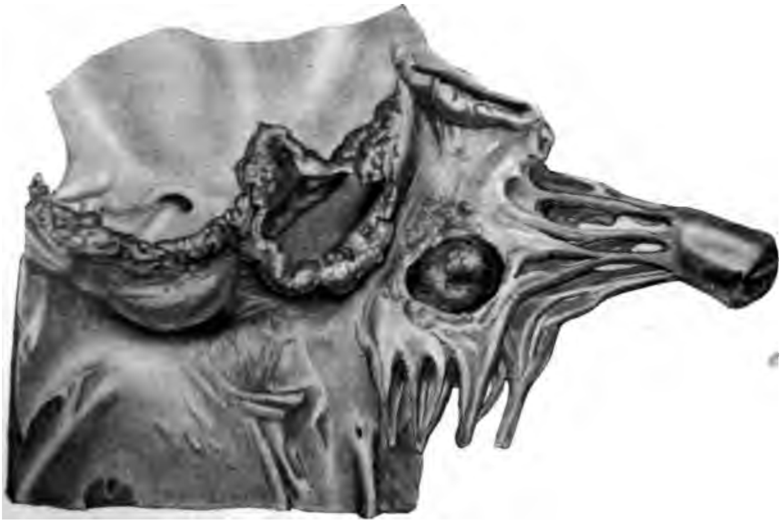


Fig. 319.—Aneurysm of the mitral valve in ulcerative endocarditis. There is in addition a large ruptured aneurysm of the aortic valve.

Aneurysm of the valves is the condition in which a pouch exists, projecting from a valve and with a narrow neck (Figs. 317, 319, and 320). It occurs in ulcerative as well as in simple acute endocarditis. With the aid of the accompanying diagram (Fig. 321), the mode of formation of the aneurysm may be illustrated in the case of the aortic valve, which is its most frequent seat. The semilunar curtains which form the valve are each composed of a double fold of endocardium, as represented at *a*. In acute endocarditis it is the ventricular layer which is principally involved along the line of contact, as indicated at The aortic layer is usually smooth and unaltered to the naked ey At the affected part of the ventricular layer the tissue is soften and during the closure of the valve the single aortic layer may unable to support the full pressure of the blood. In this way may be pushed towards the ventricle, carrying before it the soften ventricular layer, as at *c*. It will be apparent that, in the case of aortic valve, the aneurysm will always project into the ventricle. the case of the mitral valve, on the other hand, the softened lay is on the auricular surface of the valve, and the pressure of the blo during closure of the valve being exercised towards the auricle, t aneurysm consequently projects towards that cavity (see Figs. 319, 32

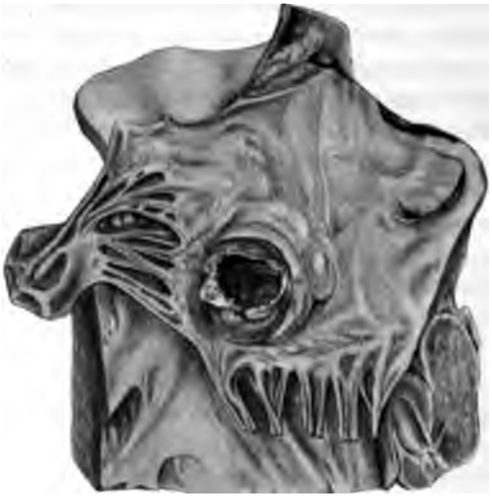


Fig. 320.—Aneurysm of the mitral valve in ulcerative endocarditis. From the same specimen as Fig. 319. Viewed from the auricular surface. The aneurysm has ruptured.

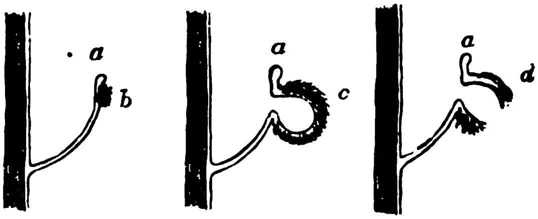


Fig. 321.—Diagram of mode of formation of aneurysm of the aortic valve. The curtain (*a*) formed of two layers; at (*b*) its outer layer roughened and softened; at (*c*) the aneurysm, which has burst at (*d*), so as to perforate the valve.

As the aneurysm owes its origin to acute endocarditis, its surface is usually covered with vegetations, which are often very abundant, and may so conceal the aneurysm as to lead to its being overlooked. The aneurysm, again, may rupture, and so produce a perforation of the valve. It is sometimes as if the bottom had been blown out of the aneurysm and a short tube left, surrounded by shaggy vegetations (as at *d* in Fig. 321). Even in that case, however, if the neck of the aneurysm be examined, it is often found that the endocardium, as it passes into it, is smooth and unaltered.

(*b*) **Chronic endocarditis** commonly follows on the acute form, and, like it, is related to acute rheumatism, chorea, etc., but it may be of more independent origin, not infrequently occurring in the aortic valve along with the similar disease of the aorta, namely, **Atheroma.** (See further on, under Insufficiency of the Aortic Valve.) It is also stated by Roy and Adami that overstrain of the heart, by acting mechanically on the valvular structures, induces œdema and subsequent thickening. In the ordinary rheumatic variety it appears as if the irritation were prolonged in a less intense form, and the changes in the valvular structures extend beyond the localities which we have seen to be mainly affected in acute endocarditis.

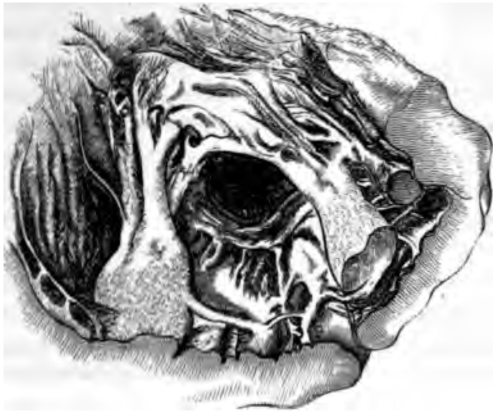


Fig. 322.—Great thickening of the chordæ tendineæ of the mitral valve, the result of chronic endocarditis.

The chronic form is chiefly characterized by new-formation of connective tissue. The granulation tissue of the acute stage develops into connective tissue, and the process extends slowly to the remaining structures of the valves. In this way arise great **thickenings** of the valves (Fig. 322), and, as the connective tissue is of that dense nature common in chronic inflammations, the thickened valvular structures are often exceedingly **rigid.** The new-formed tissue **contracts**, and in this way we may have great retractions of valves leading to serious deformities (see Fig. 323), as we shall se studying valvular diseases. Again, it frequently happens that opposed inflamed surfaces **coalesce**, and we may have still fur deformity from this, as in Figs. 324, 325, *A* and *B*. We have alre seen that the inflammation may extend from the endocardium to muscular substance, leading to cicatricial transformation of it.

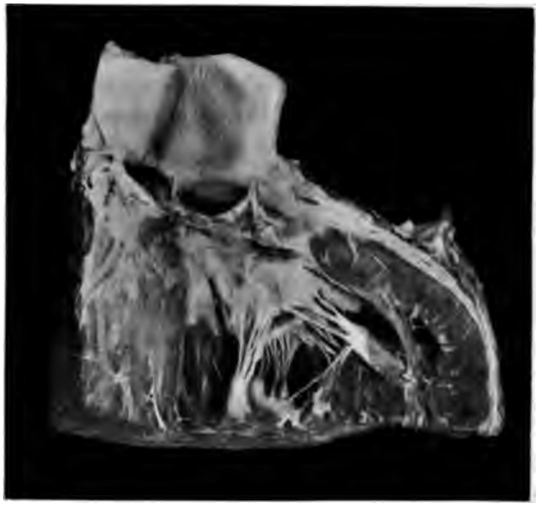


Fig. 323.—Thickening and shortening of the cusps of the aortic valve, the result of chronic endocarditis. There was marked incompetency.

In the great majority of cases, the endocarditis is limited to, or its centre in, the valvular structures, but it sometimes happens tha other parts of the heart an apparently independent endocarditis i up. This may be along with valvular endocarditis, but separated f it by sound tissue, or it may be without any valvular lesion. We find an isolated patch of thickening on the surface of the left ventr and we have already seen that the disease may penetrate into muscular substance.

The thickened and rigid connective tissue frequently becomes seat of **secondary changes.** Fatty degeneration may occur. But is much less frequent than **Calcareous impregnation**, which ma taken as evidence that the hard, dense, cicatricial connective tissue to a great extent, lost its vitality. This condition is so frequent *it may* be regarded as a normal occurrence in chronic endocar

It sometimes occurs with a very moderate degree of thickening, especially in affections of the aortic valve already referred to as connected with atheroma, and its extent and the date of its occurrence are doubtless determined by individual peculiarities. It may occur in the form of a moderate calcification in the deeper parts of the thickened tissue, or the lime salts may be deposited in a more bulky form so as to give the feeling of considerable stony masses. The occurrence of calcareous infiltration is often of serious import. The valvular struc-

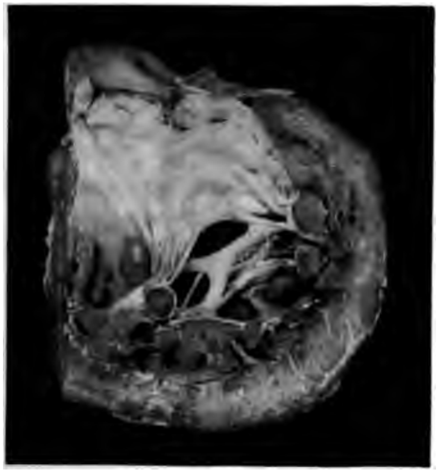


Fig. 324.—Coalescence of the cusps of the mitral valve, the result of chronic endocarditis.

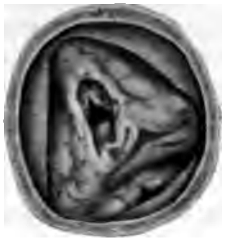


Fig. 325 A. —Greatly deformed aortic valve seen from the aorta. The greater part of the diaphragm formed by the coalescence of the cusps is infiltrated with lime. The appearance is similar to what is met with in congenital cases. Compare Fig. 284.

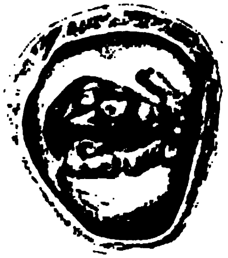


Fig. 325 B.—Another greatly deformed aortic valve seen from the ventricle. The curtains are coalesced into a rigid diaphragm. One rough surface presents calcareous matter.

tures are rendered still more rigid, and there enters the new element of brittleness. The calcified portion of the valve is exposed very often to mechanical violence in the closure of the valve, and it is common to find that the valve has been broken, as in Fig. 325 B, and a piece of calcareous matter carried off. So far as the valve is concerned, this is not very serious, but as the piece carried off is usually of some size, the resulting **Embolism** is frequently of great consequence. Embolism of the cerebral arteries leading to extensive softening is more frequent in chronic than in acute endocarditis, and probably the same applies to aneurysms of the larger cerebral arteries, which, as we shall afterwards see, may have their origin in embolism. Embolism of the spleen and kidneys is also a frequent result. The rough surface left by the breaking-off of the calcareous piece becomes coated with fibrine, and the fibrine may, by becoming detached, form a fresh source of embolism.

It is necessary carefully to distinguish from chronic endocarditis the formation of **Opaque patches** on the valves with very little thickening. These are due to fatty degeneration and are mentioned at p. 500.

(*c*) **Ulcerative endocarditis** (also called *Malignant* and *Infective endocarditis*). The special features in this disease are the activity of the destructive process in the heart, its connection with the existence of large numbers of microbes, and the virulence of the metastatic processes when emboli are carried to distant parts.

Causation.—The disease is due to the implantation of pathogenic microbes on the endocardium. Pyogenic micrococci constitute the chief form of microbe met with, but the source of these is sometimes obscure. The disease has been observed to occur in the course of a number of acute febrile affections. It is met with in pyæmia, puerperal fever, acute rheumatism, small-pox, etc., and Osler has pointed out that in a large proportion of cases acute pneumonia has been the primary disease. There are, however, cases in which no definite connection with any other disease can be traced. In the case of pyæmia and puerperal fever the source of the microbes is not far to seek, but in the other cases it is more difficult to discover. It seems probable, from the results of experiments on animals, that some previous damage to the endocardium must be inferred before ulcerative endocarditis can occur. This damage may be the result of a simple endocarditis, and the way being thus opened, the microbes may find entrance.

The micrococci from cases of ulcerative endocarditis should always be cultivated on nutrient media in order to determine their characters. They are found to possess usually the characters of the micrococci of suppuration. The Staphylococcus pyogenes aureus and albus, the Streptococcus pyogenes, as well as the Diplococcus, are found most frequently, but other forms have been identified, as for example gonococcus, bacillus coli communis, etc.

Experiments have been made by injecting cultures of these microbes into the blood of rabbits. It has been found that as a rule their simple presence in the blood is not sufficient to cause ulcerative endocarditis, but that when the valves are at the same time injured then this affection supervenes (Orth and Wissokowitsch). On the other hand, it was found by Ribbert that, when an emulsion was made of a culture of these microbes on potatoes, the injection of the emulsion was followed by ulcerative endocarditis. Apparently small particles of potato adhered to the endocardium and planted the microbes.

Characters of lesion.—In its local manifestations this form presents some resemblance to simple acute endocarditis. The disease affects, usually, the valvular structures, and produces an enlargement and roughening of them. But there is not the same localization along the lines of contact, the process generally developing in a defined area, sometimes removed from the valve. Again, the disease, as the name implies, is a much more destructive one, the parts concerned breaking down more readily (see Fig. 326). In this way perforation or aneurysm of the valve more readily occurs (see Figs. 319 and 320). Sometimes an actual suppuration manifests itself in the valvular structures, but the frequent passage of the blood prevents any considerable accumulation of pus. The ulceration sometimes passes to the muscular wall of the heart, especially when the patch of ulceration is away from the valves, and in this case the destructive process spreads rapidly in

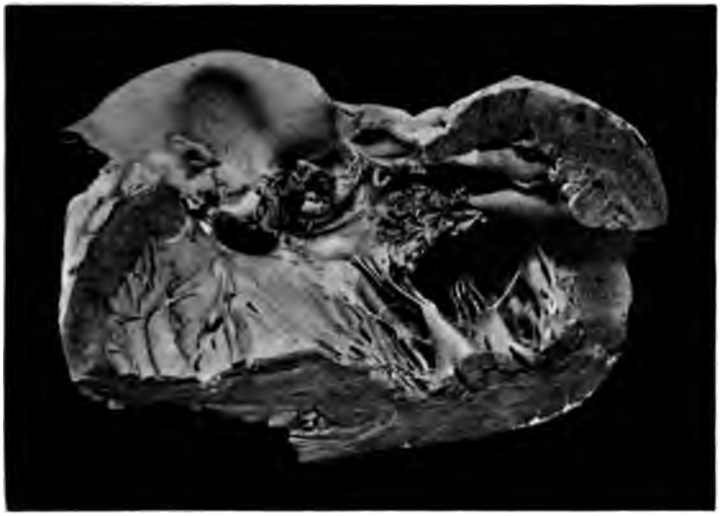


Fig. 326.—Ulcerative endocarditis affecting the aortic and mitral valves.

the myocardium, and a distinct abscess may be the result. In this way also an acute aneurysm of the heart may supervene. In the case of ulcerative endocarditis of the aortic valve extension through the pars membranacea to the right side of the heart is common. (Fig. 327.)

In their more intimate characters, also, the conditions in ulcerative endocarditis differ from those in the ordinary simple form mainly in degree. As the accompanying figure shows (Fig. 328), there is a very marked infiltration of the valvular structures with round cells, almost a suppurative condition. This is immediately overlaid by a fibrinous coagulum, as in the case of simple endocarditis, but mixed with the fibrine there are colonies of micrococci which give quite a striking character to the layer. This is more manifest in Fig. 329. The appearances in distant parts are evidence that portions are frequently carried off from the valves, and looking to the soft character of the superficial parts we are not surprised at the occurrence of **Multiple embolism.**

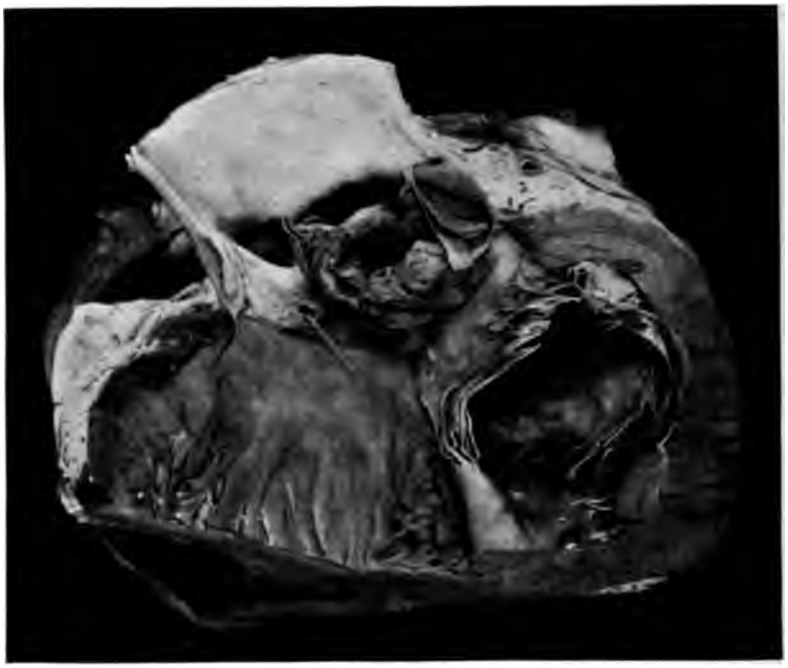


Fig. 327.—Ulcerative endocarditis of aortic valve. In the middle there is a large ruptured aneurysm and bulky vegetations surround this. There is an extension to the right side of the heart through the pars membranacea (through which a glass rod has been passed). To the left a typical ruptured valvular anourysm may be seen.

Perhaps the most striking feature in this disease is the occurrence of **Metastatic abscesses** in distant parts. These are found in the heart itself, in the spleen, in the kidneys (see Fig. 206, p. 374), in the skin, etc. They are everywhere of small size, and usually in large

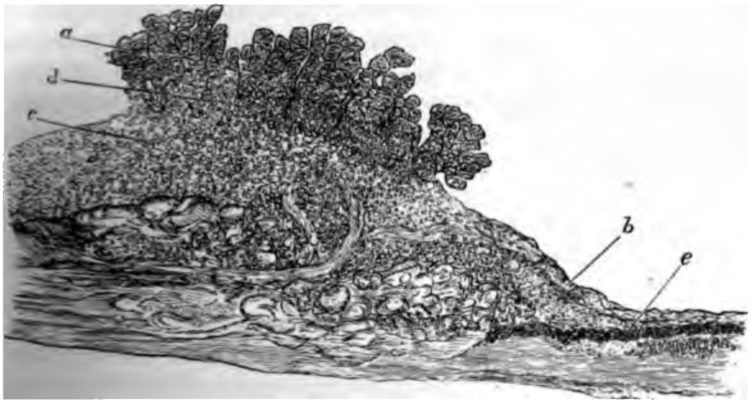


Fig. 328.—Portion of a valve in ulcerative endocarditis. *a*, Fibrine with colonies of micrococci; the colonies are indicated by the roundish clumps; *b*, endocardium becoming raised by inflammatory infiltration; *e*, elastic layer of endocardium; *c*, round cells infiltrating endocardium, at *d*, passing into the superficial layer of fibrine. × 22.

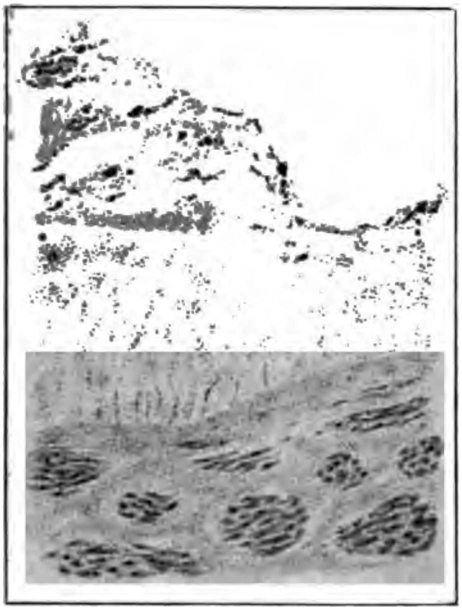


Fig. 329.—Ulcerative endocarditis. Vegetation from below aortic valve. Groups of staphylococci are seen on the surface. There is evidence of organization from the endocardium at the lower part of the specimen. × 50.

numbers. These abscesses are obviously related to emboli carried off from the endocardial lesion, and lodged in the finer arteries or capillaries. The accompanying figure (Fig. 330) represents a small artery in the midst of an incipient abscess in the kidney. It is seen that its calibre is plugged by a material in which are masses of micrococci. At the distal part the wall of the artery is obscure, apparently from necrosis, and the vessel is buried in an enormous aggregation of leucocytes. The micrococci are frequent in the capillaries and Malpighian tufts, but not generally with obvious inflammation; apparently they are in that case of recent development, possibly to some extent post-mortem, and their products have not had time to produce inflammation.

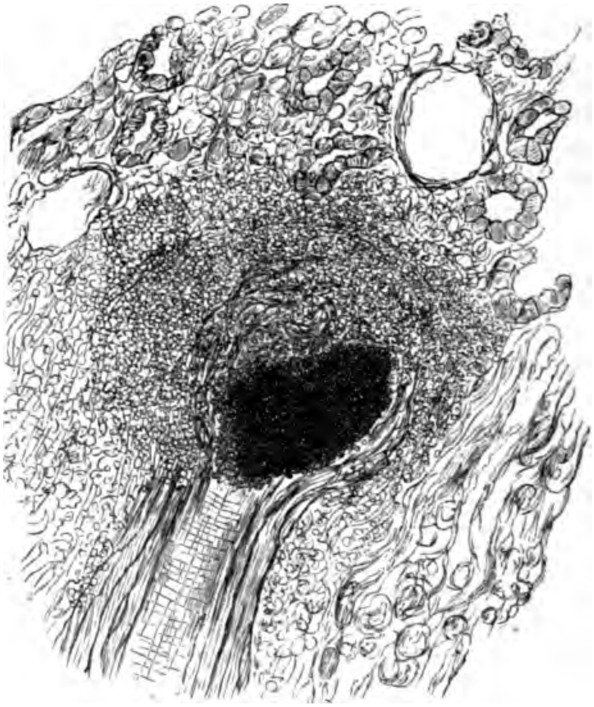


Fig. 330.—From the kidney in ulcerative endocarditis. An artery is shown, plugged with dark material containing micrococci. Around these are myriads of leucocytes which are infiltrating the necrosed wall of the vessel and the kidney tissue around. × 90.

We have seen that the micrococci have, locally, an intensely irritating action, and that necrosis of the tissue attacked is a common result. They also produce changes in the constitution of the blood. Patients affected with this disease frequently present, like those in pyæmia, a yellow colour of the skin approaching to that of jaundice. The probable explanation of this is, that the blood-corpuscles undergo solution, and the colouring matter stains the skin. Besides that, we often have little ecchymoses of the skin, and small **Hæmorrhages** in the pia mater, and even in the brain substance. These have been found associated with the presence of colonies of micrococci in the capillaries, and are to be ascribed to the action of these in weakening the wall, and allowing the escape of blood.

3. **Pericarditis.**—The pericardium in its anatomical and pathological relations corresponds with the other serous sacs, and, to a certain extent, with the synovial cavities. The pleura, peritoneum, and pericardium are to be regarded, as we previously found in studying œdema and dropsy, as large lymphatic spaces. These sacs are composed of connective tissue, and are lined with a single layer of flat endothelium. By means of numerous stomata they are in communication with the lymphatic vessels, and to some extent with one another. The pericardium is in less direct communication with the pleura and peritoneum than these are with each other, but by circuitous routes there is some communication, especially with the pleura. It is to be remembered also that through each serous cavity there is a certain circulation of serous fluid. This fluid does not accumulate in the sac, because it is carried off as quickly as it is transuded from the vessels, but if the transudation increase greatly there may be an accumulation and consequent dropsy.

(*a*) **Acute pericarditis.**—In considering the **Causes** of this disease it is of some consequence to note that the inflammation usually affects the whole surface at once. This seems to indicate that an irritant has found admission to the pericardial sac, and by the motion of the heart and the natural currents of the fluid in the sac, has been carried hither and thither throughout it. There are many cases in which the **tubercle bacillus** is the irritant; we find tubercles in the inflamed tissue of the pericardium. (See afterwards under Tubercular Pericarditis.) The majority of cases of simple pericarditis is associated with acute rheumatism. There are some cases in which the disease appears to be of spontaneous origin; it is ascribed to cold. Bright's disease in its various forms strongly predisposes to inflammations of the serous membranes, especially the pericardium and pleura.

In regard to the **Phenomena** which manifest themselves at the onset of an acute pericarditis, we may presume that the irritant induces the changes in the vessels which have been described in treating of inflammation in general, but opportunities are wanting for observing the consequent redness as patients survive this early stage. **Exud** from the vessels soon follows, and **serous fluid** begins to accumul the sac. As the inflammation affects the surface of the sac, the thelial lining is very directly involved. The flat endothelial cel to a considerable extent shed, being apparently killed by the irr but they may also be found showing signs of prolifieration. The e tion consists primarily of exuded liquor sanguinis with contractile

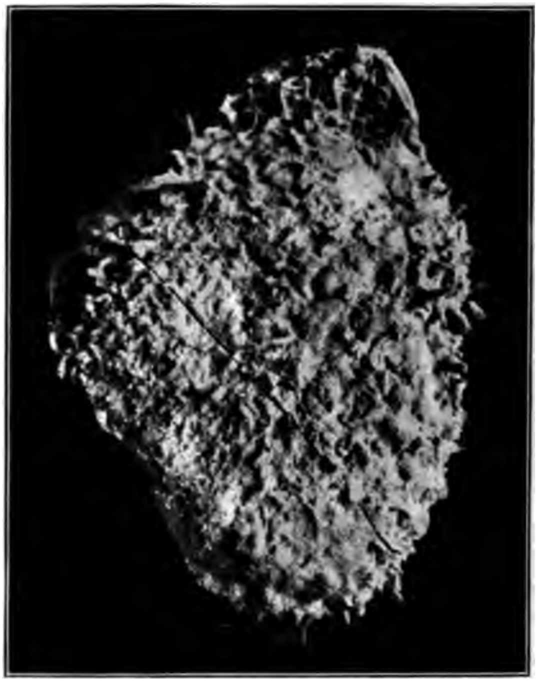


Fig. 331.—Acute pericarditis. The entire surface is covered with a thick shagg layer of fibrine.

but soon **Fibrine** is deposited on the inflamed surface. (See Figs. 332, and Fig. 32, p. 118.) The detachment of the endothelium s to be the circumstance which determines the coagulation, on prin already explained. The deposition of fibrine occurs on both viscera parietal layers of the sac, but it is usually thickest on the viscera face, where it may present shaggy masses on the surface of the (see Fig 331). It is whitish in appearance, and of soft, almost ge ous consistence. The fibrinous layers on the opposed surfaces c pericardium are usually separated by serous fluid which occupi sac, but an appearance is often presented which suggests the applic and withdrawal of the layers while still in a soft plastic condition. This appearance is variously described as the **Honeycomb** or **Pine-apple** condition, and it has been aptly compared to that presented when two pieces of bread, thickly buttered, are stuck loosely together and then separated (see Fig. 332). This honeycomb appearance, it will be understood, is most markedly present on those parts of the pericardium where the heart in its movement comes most frequently against the parietes. In some cases the exudation has a distinctly hæmorrhagic character (Fig. 333).

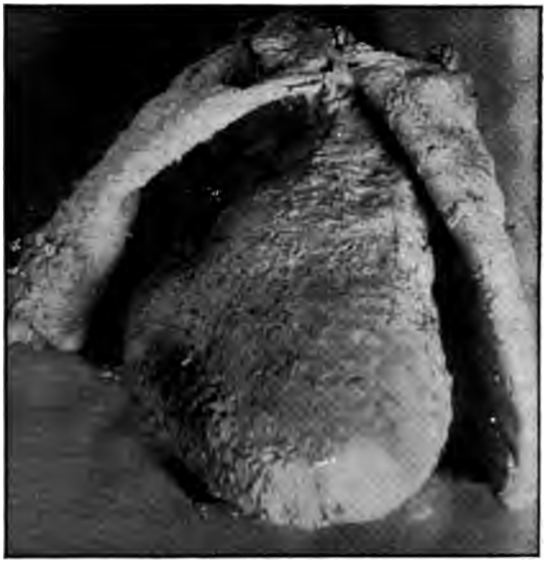


Fig. 332.—Acute pericarditis. The surface of both visceral and parietal layers of the pericardium is coated with fibrine.

The exuded fibrine has the usual characters, as seen under the microscope forming a reticulum in the meshes of which are leucocytes and sometimes red corpuscles.

If the inflammation has been slight and transient, there may be little beyond a small serous and fibrinous exudation, which is gradually absorbed. But as a general rule further changes develop, and these are mainly in the connective tissue of the pericardial sac. This shows evidence of inflammation by the presence of innumerable cells, so that by degrees it is converted into **Granulation tissue**. This inflammatory transformation, according to the intensity of the irritation, penetrates deeply, extending frequently to the interstitial connective tissue in the muscular substance of the heart. A layer of vascular granulations thus forms beneath the fibrinous exudation. The layer of granulations has the general tendencies as well as the structure of granulation tissue elsewhere; it tends to develop into connective tissue as soon as the inflammatory irritation becomes sufficiently mild. With the subsidence of the inflammation there is a reduction of the serous exudation. The fibrine is also disposed of, partly undergoing fatty degeneration and so becoming absorbed, and partly eaten into from beneath by the granulation tissue. The result of this is that the granulations are, as it were, laid bare, and a vascular layer occupies the place of the former fibrinous deposit.

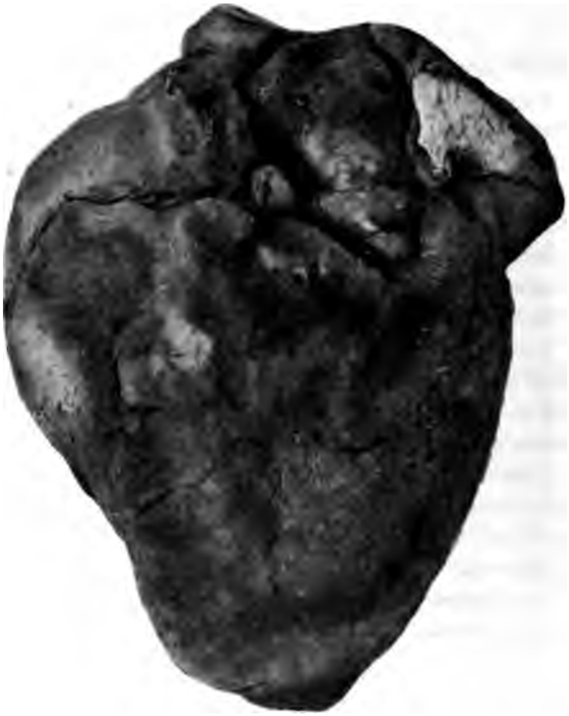


Fig. 333.—Hæmorrhagic pericarditis. The posterior surface of the heart is shown.

With the absorption of the exudation the two layers of the pericardium come in contact, and a coalescence of the granulating surfaces, more or less complete, occurs (Fig. 334). The vessels intercommunicate, and the two layers, so far as they are in contact, become virtually one. As the granulation tissue passes on in its development into connective tissue, the **Pericardial sac undergoes** partial or complete ***obliteration,*** the uniting agent being vascular connective tissue, and so we have the condition of **Adherent pericardium.** The connection is at first delicate, and may be torn through, but as time goes on it becomes firmer, and a condition results in which the two layers are absolutely inseparable. Under certain circumstances the coalescence of the two layers is not complete; there is only a partial adhesion. In that case the adhesions are sometimes greatly stretched by the movements of the heart, so that tags or ligaments may unite the visceral to the parietal layer.

In some intense and prolonged cases of acute pericarditis, **Suppuration** occurs, and the serous exudation in the pericardium gives place to pus. This, however, is a rare occurrence. On the subsidence of the inflammation the pus dries in by the absorption of its fluid, and its debris remains as dead matter, which subsequently often becomes infiltrated with lime salts; this may ultimately become consolidated so as to form calcareous plates in the midst of thick adhesions (see p. 500).

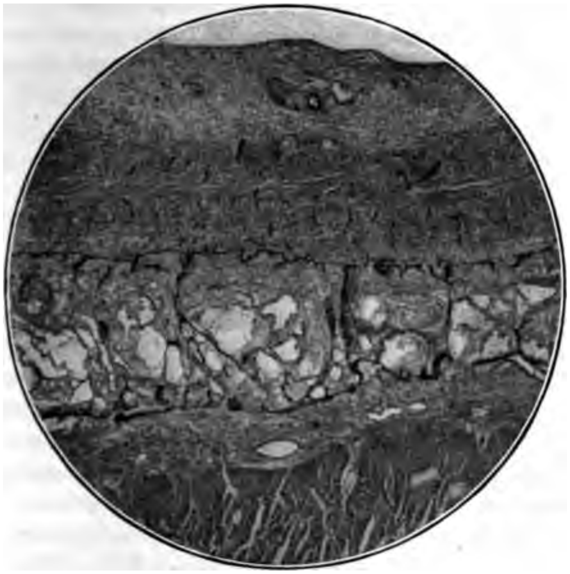


Fig. 334.—Pericarditis with adhesion. The bond of union between the visceral and parietal pericardium is shown. Organization is in progress. × 17.

Septic inflammations, such as those which occur in pyæmia when an abscess in the substance of the heart extends to the surface and bursts into the pericardium or gives off septic microbes, or in the rarer case of perforation of an ulcer of the stomach or œsophagus into the pericardium, are purulent from the outset.

Adherent pericardium usually leads to **Hypertrophy and Dilatation of the heart.** It does so both directly by interfering with the muscle, and indirectly by requiring the heart to use increased exertion in performing its task.

It should not be forgotten that adhesion of the pericardium takes origin in inflammation, and from this circumstance it results that in several ways the action of the heart is interfered with. During the acute stage of the inflammation there is fluid in the sac of the pericardium, and by the mere mechanical pressure of this fluid the cardiac contractions are interfered with, and if the effusion continue long enough there may be hypertrophy to overcome the obstacle. Again, the inflammation extends a certain distance into the muscular wall of the heart beneath the pericardium. A certain portion of muscle is thus interfered with in its action, and more vigorous contraction is required of the rest. There may even be considerable thickening of the pericardium by development of connective tissue, which often extends some distance between the muscular fibres and may seriously compromise them. But further, when adhesion is complete, the heart in contracting must drag in with it the parietal as well as the visceral pericardium. In the normal state the two surfaces of the pericardium glide on one another, and the parietal layer accommodates itself to the movements of the heart. If there is adhesion, however, unless the adhesion be very loose, there can be no such gliding, and there must be some loss of force in dragging the parietal layer inwards. But the parietal layer is normally attached to the under surface of the sternum and to other structures around, and the attachment may be rendered closer by the inflammation. The heart will drag on these parts in contracting, and this will greatly add to its work. It is well known that dragging in of the intercostal spaces is a common sign of adherent pericardium. As these causes vary to a considerable extent, the amount of hypertrophy varies in proportion. As the causes also act nearly uniformly on the heart, the hypertrophy is general, that is, it usually affects all the cavities of the heart. Such a hypertrophy may almost completely compensate, so that a person with adherent pericardium and a very large heart may show no cardiac symptoms.

(*b*) **Chronic pericarditis.**—As observed above, acute pericarditis often becomes chronic, and, in that case, usually results in adhesion of the pericardium. A more localised chronic inflammation results in the condition designated **White spots, Milk spots,** or **Soldier's spots,** which are very common pathological conditions. They occur in about half the cases examined post-mortem, and their frequency seems nearly in direct proportion to age. They are in the form of well-defined, whitish, opaque areas on the surface of the heart, of very various size, sometimes very small, at other times so large as almost to cover the anterior surface. Their edges are usually abrupt and well defined, but they may merge gradually into normal pericardium. They have often a brilliant white tendinous appearance, but may be more dull. They are most frequently situated on the anterior surface of the right ventricle, and next on that of the left ventricle, especially near the apex. They are also met with on the posterior surface, especially near the base of the heart, and on the intrapericardial portions of the great vessels. They are less common on the parietal layer of the sac.

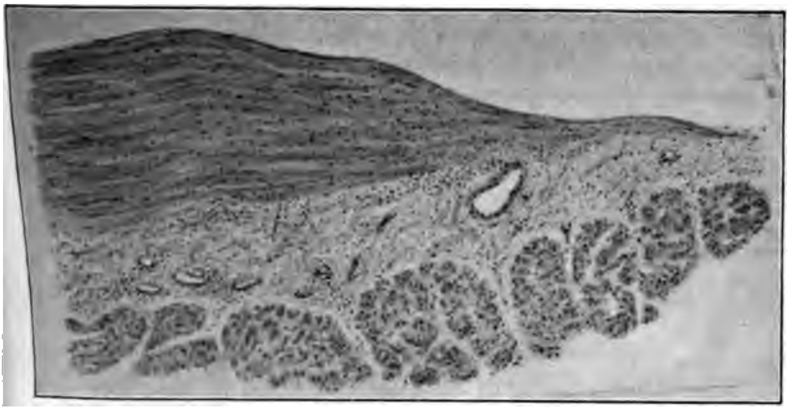


Fig. 335.—Soldier's spot on pericardium. × 40.

These spots actually consist in a thickening of the pericardium, presenting merely dense connective tissue covered with endothelium (see Fig. 335).

We have here a circumscribed inflammation affecting by preference certain districts, and the cause must be a local one. It seems to be due to the irritation resulting from the projection of the heart against its surroundings. The commonest seat is where the anterior surface of the right ventricle comes against the sternum at the place where the edges of the lungs turn aside and expose the pericardium. The sternum is less yielding than most surrounding parts, and so the irritation here is greater. The spot where the left ventricle near the apex strikes against the fifth rib is the next most frequent site. Here the patch may be considerably raised above the general surface. Occasionally it assumes a rosette form (see Fig. 336).

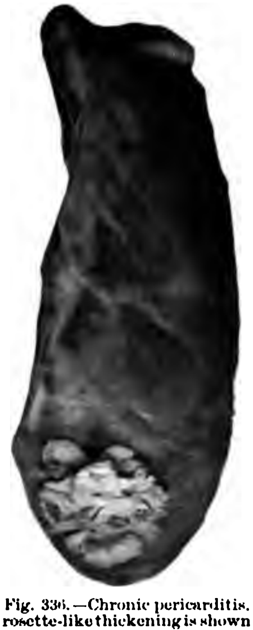


Fig. 336.—Chronic pericarditis. A rosette-like thickening is shown at the apex of the left ventricle.

VII.—VALVULAR DISEASE OF THE HEART.

In studying endocarditis we have seen that the valves are frequentl altered in their structure; we have now to consider these alteration more specifically, and their effects on the heart and circulation. It i not usual to designate anything as valvular disease unless it interfere with the function of a valve or orifice. The function of a valve is t close an orifice under certain circumstances, and we speak of valvul disease when the alterations are such as either to obstruct the orifice o to interfere with its closure by the valve. Hence valvular lesions ma be divided into two kinds, namely, narrowing or stenosis of the orific and insufficiency of the valve. In referring to these same lesions, a they affect the current of blood in the heart, we speak of obstructio of an orifice and of regurgitation through the orifice.

Valvular disease occurs much more frequently in the valves of th left side than in those of the right, and hence we have chiefly to d with the mitral and aortic valves. We have already seen that in th fœtus it is the valves of the right side which are most frequentl affected, and we have connected this with the fact that these valves ar more liable to variations of pressure in the fœtus than in the adult.

1. **Insufficiency or Incompetency of the mitral valve.**—This is a condition i which, during the systole of the heart, some portion of the blood passes back int the left auricle instead of the whole being forced into the aorta.

The actual physical conditions are somewhat various, but most of them a related to chronic endocarditis. The commonest is that in which the valvul structures are thickened by the new-formed connective tissue and retracted a shortened from its contraction. This applies to the curtains themselves, but st more to the chordæ tendineæ, which become thickened and shortened, and frequent grow together, so that they hold the curtains rigidly drawn down and do not all them to go together during the systole of the ventricle (see Figs. 322 and 324, pp. 51 519). Again, irregularities of the borders may lead to imperfect apposition of the edg and a certain amount of insufficiency. This, however, although it may lead to loud murmur during life, can scarcely produce a serious functional disturbance. the other hand, but more rarely, in acute endocarditis the valve may be perforat as in the case of valvular aneurysm, or the chordæ tendineæ torn so as to allow portion of the valve to flap upwards through the orifice. Lastly, without mu alteration of the curtains, there may be a **relative insufficiency** of the valve. Th is to say, the cavity of the ventricle sometimes enlarges greatly, and produ enlargement of the orifice, which the valve is no longer able to cover. There some cases of permanent hypertrophy and dilatation of the left ventricle (as fr overstrain) where this occurs, but it may be met with where the dilatation temporary, as in the flabby fatty heart of typhus fever and anæmia. It is not to supposed that the so-called anæmic murmurs are usually due to this cause, there is in some cases of anæmia an actual mitral regurgitation. When recove occurs, and the heart resumes its former vigour, the valve will again cover orifice.

The results which follow constant insufficiency of the mitral valve are frequently very serious and far-reaching. At each ventricular systole blood regurgitates into the left auricle, and the most direct result is over-distension of this auricle occurring at successive intervals. The auricle does not usually suffer great enlargement from this cause. There is another result which often follows, apparently from the unduly forcible impact of the blood against the endocardium, and the overstretching of this membrane, namely, a thickening of the endocardium. We may find it generally thickened and opaque, or there may be patches of opacity.

But the results do not confine themselves to the auricle—the abnormal blood-pressure is reflected to the **Pulmonary veins** which feed the auricle, and they become distended. The distension is further reflected to the pulmonary capillaries and arteries, and finally to the right ventricle. The right ventricle in turn becomes over-distended, and, as a consequence, **Hypertrophy of the right ventricle** occurs. The obstruction to the circulation may then extend to the right auricle and finally to the venæ cavæ. In this way **General venous engorgement** comes about with all the consequences which will be described in the next section in dealing with mitral stenosis.

The amount of blood which the left ventricle sends into the aorta will be diminished in proportion as more or less passes back into the auricle. In consequence, the systemic circulation will be partially starved. In some cases the left ventricle undergoes hypertrophy. This is mainly due to the fact that at each diastole it will receive from the distended auricle an excess of blood, namely, that which arrives from the pulmonary veins along with that which regurgitates from the ventricle. The ventricle having thus to deal with an increased mass of blood undergoes dilatation and hypertrophy.

2. **Obstruction of the mitral orifice. Mitral stenosis.**—This name is applied to the condition in which the mitral orifice is not large enough to allow of the usual quantity of blood passing from the auricle to the ventricle. **The normal width** of the mitral orifice may be roughly estimated with the fingers; in the adult it should allow the index and middle fingers to pass freely through as far as the first joint. The contraction may be very slight or it may be so marked that hardly a crow-quill will pass through the orifice. In the case of stenosis of the mitral orifice, as well as in that of the aortic orifice, the obstruction is usually caused by the curtains of the valves becoming thickened and rigid, but especially by their coalescence. The thickened curtains grow together by their edges, and so the valve is converted into a funnel with its apex turned down into the ventricle—the so-called **Funnel-shaped deformity**. The normal orifice is at the base of the curtains, but when the curtains coalesce, the orifice, while becoming contracted, is moved downwards and comes to have its site at the apex of the funnel. This will be understood from the accompanying diagram (Fig. 337), in which black lines

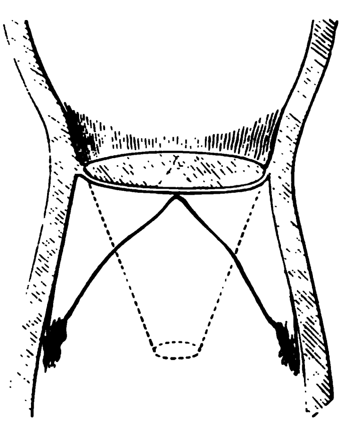


Fig. 337.—Diagram of funnel-shaped deformity of mitral valve. The dotted lines indicate the coalesced curtains forming a funnel projecting into the ventricle with a reduced aperture at the apex.

represent the orifice and curtains in their normal condition during the diastole of the ventricle, the curtains lying back against the wall of the ventricle, and th orifice at their base. The dotted lines represent the coalesced funnel-shaped valve the contraction of the orifice and its removal downwards being shown. The chordæ tendineæ are commonly thickened, and often partly incorporated in the funne (see Figs. 322 and 324, pp. 517, 519). On laying open the ventricle this thick, rigid funnel-shaped deformity is often strikingly prominent. These conditions result fro chronic endocarditis, and it will be readily understood that the rigid valve frequently incompetent, so that this condition is often combined with the o before mentioned. There are also, not infrequently, changes in the aortic valv

Obstruction is occasionally produced by thrombi growing on the valve, or havi their seat in the auricle and projecting into the orifice. This is a rare cause obstruction, and a still rarer is the presence of tumours growing in such a way as obstruct the orifice.

It might be supposed that the vegetations occurring in acute endocarditis wou obstruct the orifice, but although these rough projections undoubtedly interrupt t even flow of blood, and may produce during life a murmur of mitral obstructio yet their actual influence on the function of the orifice must be very slight, and need not look for any definite evidences of their influence on the circulation.

We have now to consider the **effects** on the circulation of mitral obstructio The most direct effect will be **dilatation of the left auricle**, as the blood is to certain extent hindered in its passage into the ventricle. As a consequence, th whole of the pulmonary vessels will be loaded and the right ventricle distended wit the accumulated blood. On the principles already laid down there will be increase action and consequent **Hypertrophy of the right ventricle**, and this is commonly more extreme than in mitral insufficiency. The contraction of the orifice interferes with the passage of blood into the **left ventricle**, which, in extreme cases, is, as it were, starved of blood. The increased force of the right ventricle may in great part make up for the deficiency, and sometimes there is also aortic insufficiency, so that the ventricle is fed from the aorta as well. According to these various circumstances will be the state of the left ventricle. It may be actually atrophied and appear a a small appendage to the enlarged right ventricle, or it may be normal in size o even hypertrophied. In any case the hypertrophy of the right ventricle is th predominating condition. The shape of the heart is more quadrilateral, the ape is blunt and formed by the right ventricle. During life instead of the defined ape beat of the left ventricle, there is the more diffuse heaving of the right.

As a further consequence, we have a permanent **Passive hyperæmia of the pul monary circulation**, with consequent brown induration of the lungs. There is als a tendency to slight hæmorrhages, the blood showing itself in the sputum. Th dilatation of the right ventricle, when followed by thrombosis in the auricl or ventricle, also frequently leads to embolism of the pulmonary artery an hæmorrhagic infarction. The hyperæmia is reflected to the **systemic venou circulation**, especially if the dilatation of the right ventricle lead to relative in sufficiency of the tricuspid valve, and we find evidences of passive hyperæmia of th liver (nutmeg liver), kidneys, and other organs. Not infrequently serious œdema o the skin and dropsy of the serous cavities develop. Thrombosis in the veins of th legs often complicates the condition, and this again may be a source of pulmonar embolism.

3. Insufficiency of the aortic valve.—This is the condition in which, after th completion of the ventricular systole, a portion of the blood regurgitates into th left ventricle through the imperfectly closed semilunar valve. It is usually brought about by chronic endocarditis. The individual semilunar folds are thickened and shortened, the actual length of free margin being reduced. The consequence is that during the closure of the valve, the edges have not sufficient length to meet perfectly and so a triangular aperture is left. This is illustrated diagrammatically in the accompanying figure (Fig. 338). The contraction may reach such an extent as to leave only a nodulation on the wall of the aorta in place of the curtains. These changes are very commonly accompanied by adhesion of the adjacent folds of the curtains and this necessarily causes contraction of the orifice; indeed, the curtains as such may disappear, leaving only a diaphragm with a permanent aperture in its middle, the condition being illustrated in Figs. 325B and 325A, p. 519. An unusual cause of aortic insufficiency is **Perforation of the valve** as a result of acute endocarditis or the bursting of a valvular aneurysm. Of course the perforation of the curtains beyond the line of contact already referred to is not to be mistaken for a pathological perforation. A rare cause of aortic insufficiency is the **Tearing of one of the curtains.** During severe exertion the blood-pressure in the aorta may be so much raised as to rupture a curtain, and such a wound does not tend to unite, as it will be torn asunder at each systole.

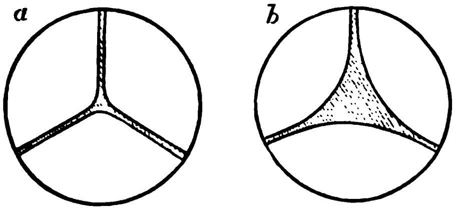


Fig. 338.—Diagram of aortic insufficiency. *a*, The normal valve closed as seen from above; *b*, the valve with curtains shortened and leaving a triangular space.

It may be added here that aortic disease is often accompanied by mitral disease, chronic endocarditis, having its origin in rheumatism, usually attacking both. Chronic endocarditis of the aortic valve again is often connected, as we have seen, with endarteritis or atheroma of the aorta, and in that case it is not so likely to be associated with mitral disease.

It may be noted here that the origin of endocarditis has an important bearing in view of the **Age at which these valvular lesions occur.** Acute rheumatism is a disease of youth and manhood, and most cases of valvular disease occur at that time of life. Accordingly, diseases of the valves are most common, at least in their inception, between the ages of ten and thirty. But there are some cases of aortic disease which, as we have seen, stand in a different category. Chronic endarteritis or atheroma is a disease mostly of advanced life, and so it is more common in old persons to meet with aortic disease than with mitral.

We have now to consider the **Effects** of this insufficiency of the aortic valve on the circulation. As the semilunar valve does not close completely, the aorta in its recoil after the ventricular systole will force blood back into the ventricle as well as forward into the systemic arteries. This extra mass of blood driven with considerable force into the left ventricle will overfill it and forcibly distend it, while the systemic circulation will be proportionately starved. The natural result is **Dilatation and hypertrophy of the left ventricle,** the latter of which may almost completely compensate. In this disease, therefore, the primary and prominent fi is the enlargement of the left ventricle. As the ventricle propels a much lar amount of blood into the aorta, and with abnormal force, there is sometime resulting **Dilatation of the arch** and great vessels. In this way there may be p duced an actual aneurysm of the arch.

It is to be added, that as hypertrophy of the left ventricle is associated w dilatation of that cavity, there is frequently a consequent widening of the mi orifice. As a result of this, we may have a relative incompetency of the mi valve, which is incapable of completely covering the dilated orifice. In this w the consequences already considered of **Mitral insufficiency** may be brought abo but they are usually much less pronounced than in the primary form of this lesi and of late occurrence. It is to be remembered, also, that mitral disease of co-exists with aortic.

4. **Obstruction of the aortic orifice. Aortic stenosis.**—In this lesion the pass of blood from the left ventricle into the aorta is interfered with. It is, in great majority of cases, caused by chronic endocarditis. The conditions alre described as leading to insufficiency of the valve mostly produce also obstruct of the orifice, by causing rigidity of the curtains, and this is all the more mar when calcareous infiltration ensues. Where the valve is, in the way alre mentioned, converted into a rigid diaphragm, then there must be great obstruct of the orifice as well as insufficiency of the valve. These two forms of le are, therefore, usually found associated. In acute endocarditis the roughenin the curtains may to some extent obstruct the flow of blood, but the interfere is trivial, and will hardly lead to any of the secondary results of aortic stenosis.

The obstruction at the orifice prevents the blood getting away fully during systole of the ventricle, and there comes to be an overfilling of the ventri The ventricle, as in the previous case, is stimulated to increased exertion, so here also the primary phenomenon is **Hypertrophy of the left ventricle.** T may completely compensate for the obstruction, and persons may go about co paratively well with an obstructed orifice and enlarged left ventricle. But thi not so likely as in the previous case, and any need for extra exertion on the part the heart, or weakness of its muscles, may lead to incomplete compensation. such a case the ventricle will get abnormally dilated, and the auricle will not be a to empty itself fully into the dilated ventricle. The **Pulmonary circulation** v become engorged and the **Right ventricle** overloaded, and so we may have the evil consequences of mitral disease. The left ventricle is much more capa of undertaking additional work than the right, it therefore succeeds much m frequently in bringing about a complete compensation. The hypertrophied ventricle having to dispose of an increased mass of blood, generally does slowly, and the pulse is consequently slow and regular.

5. **Valvular disease of the right heart.**—We have already seen that, except the fœtus, this form of disease is uncommon as a primary lesion. In case acute or chronic endocarditis with well-marked lesions on the left side, howe there are very often distinct indications of inflammation in the valves of right heart. (Fig. 339.)

Relative insufficiency of the tricuspid valve, although secondary, is often considerable consequence on account of the effects to which its leads. We h seen that in mitral disease the right ventricle usually dilates and hypertroph and with this change in the ventricle the orifice widens. The valve may thu unable to cover the enlarged orifice, and may become insufficient.. In other form dilatation and hypertrophy of the right ventricle as in that due to obstruction of the pulmonary circulation, the same thing may occur. The tricuspid orifice normally admits readily three fingers up to the first joints, and when enlarged it is not uncommon to meet with cases in which it admits four, five, six, or even seven fingers. If the valve is thus incompetent to close the enlarged orifice the blood will, during the systole of the ventricle, regurgitate into the auricle. The wave will be propagated into the veins of the neck, and there will probably be an aggravation of the existing congestion of the systemic veins.

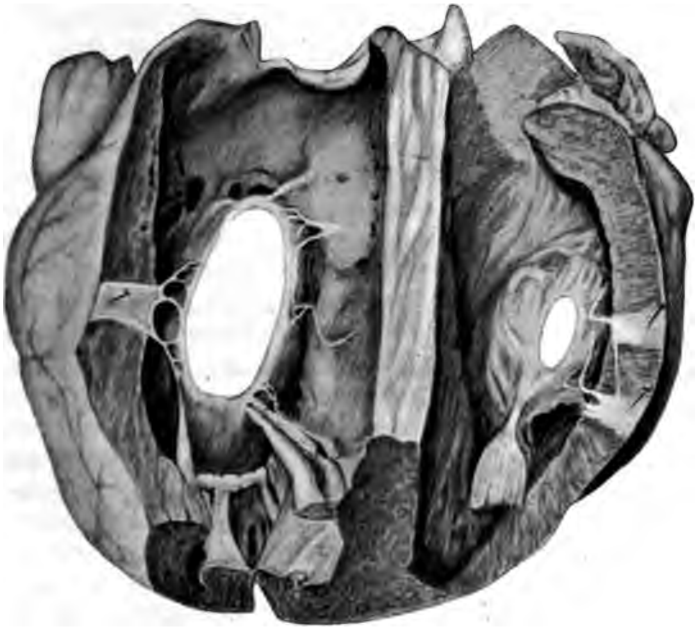


Fig. 339.—Tricuspid and mitral stenosis.

It need only be added, that if chronic endocarditis attacks the tricuspid or pulmonary valves, it may produce results similar to those effected in the mitral and aortic. The tissue here, however, is less substantial to begin with, and the inflammation is usually much less intense, and so the changes are rarely of any great consequence.

VIII.—TUBERCULOSIS AND SYPHILIS, Etc.

1. **Tuberculosis.**—This is rare as a lesion of the heart itself, but is frequent and important in the pericardium. **Tuberculosis of the heart** as an occasional accompaniment of acute general tuberculosis, is not infrequent in children. Characteristic nodules in the muscular substance and in the endocardium occur, but in some cases a more definite **tubercular endocarditis** has been observed with the usual features of an acute endocarditis.

Tubercular pericarditis arises by infection from some part i neighbourhood of the heart. This is usually the mediastinal ((Weigert), but may be the pleura. A tuberculosis of the medi glands may slumber on for many years, and an accidental ext to the parietal pericardium may result in the launching o infective agent into the sac. The bacillus is dispersed throu the sac, where it multiplies and produces its toxin.

At the outset there is usually an acute inflammation wit features of acute pericarditis described above, but there is not u much serous exudation. A fibrinous deposit is formed beneath small miliary nodules are visible. As the disease becomes cl there is great new-formation of connective tissue and of tub The process occurs in both the visceral and parietal layers c pericardium, and the two layers are liable to coalesce so that adl pericardium results. The condition, however, differs greatly ordinary adhesion of the pericardium in respect that there is great thickening. In the case from which Fig. 340 is take pericardium had a thickness of 1·5 to 2·5 cm. The heart was encased in a dense thick capsule which must have greatly im its movements.

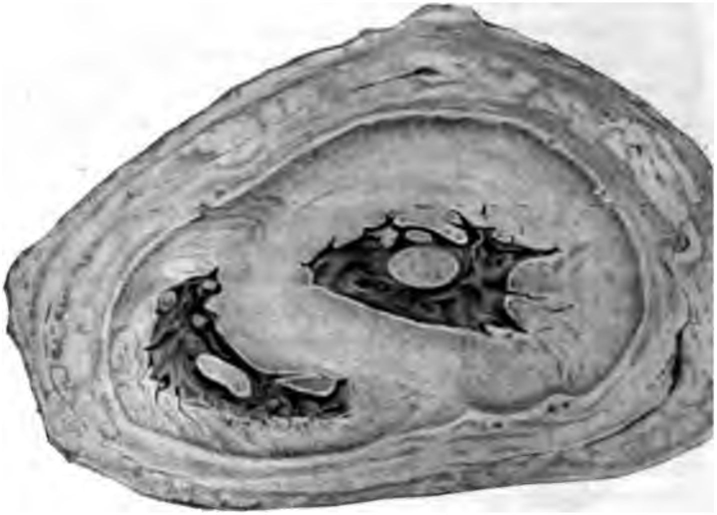


Fig. 340.—Tubercular pericarditis. The ventricles are shown in section. There very great thickening of the pericardium, and the two layers have coalesced.

In the thick adherent pericardium it is usually possible t tinguish two layers of tubercles, one belonging to the visceral one to the parietal layer of the pericardium. Under the microscope there will be found large masses having the indefinite characters of caseous necrosis with occasional fresh tubercles, in the midst of tissue which presents in some parts evidences of recent inflammation and in others merely dense connective tissue. (See Fig. 341.)

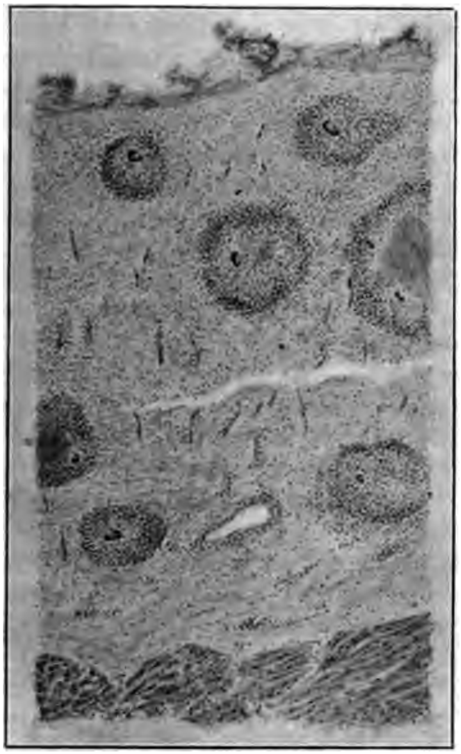


Fig. 341.—Tubercular pericarditis. In the lower part the heart muscle is shown. Surmounting it is a thick vascular layer with numerous tubercles. On the surface is a layer of fibrine. × 50.

2. **Syphilis.**—This occurs in the heart chiefly in the form of **gummata** which have their seat in the muscular substance in any region. The gumma, which may attain considerable dimensions (see Fig. 342), is a dense tough body of somewhat indefinite structure, and it is surrounded in the usual way by cicatricial connective tissue which replaces the muscular substance, producing an interstitial myocarditis (see Fig. 57, p. 181). The endocardium and pericardium are thickened, and the latter may show adhesions. Besides the gummata a limited fibrous induration may have a syphilitic origin

(see Fig. 294, p. 492). A syphilitic affection of the valves has been described, but is very rare.

Actinomycosis and **Hodgkin's disease** may extend from the mediastinum and lungs to the pericardium and heart, but are not independent diseases.

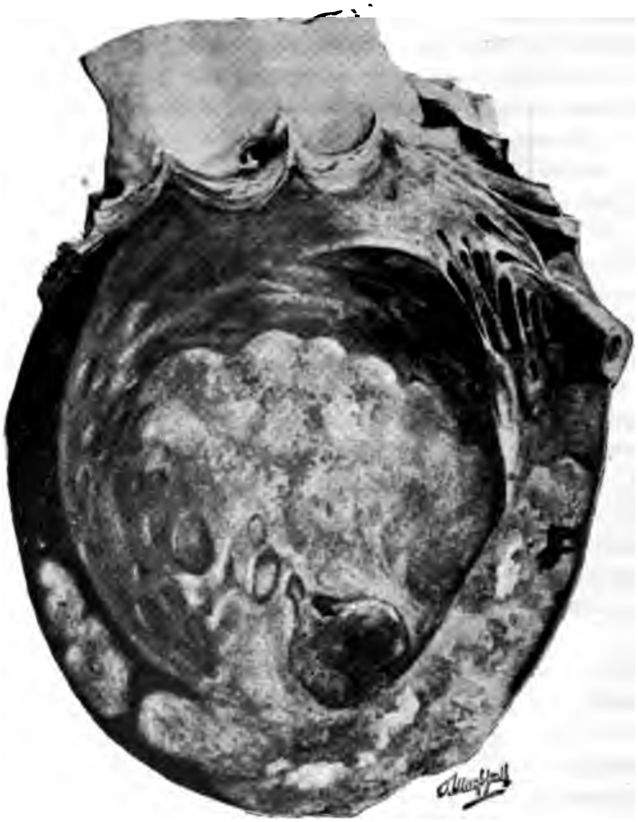


Fig. 342.—Gummata in wall of left ventricle. A large portion of the wall is occupied by gummatous tissue. (From a coloured drawing by Dr. Alex. Macphail.)

Literature.—*Tuberculosis.*—Tripier, Arch. de méd. expér., 1890; Weigert, Virch. Arch., vol. lxxv., 1879; Pollak, Zeitsch. f. klin. Med., xxi., 1892 (literature). *Syphilis.*—Virchow, Geschwülste ii., 441, 1865; Lancereaux, Traité de la Syph., 1873; Lang, Path. und Ther. der Syph., 1896; Syph. des Herzens, 1889; Volmar, Ueber Gummata des Herzens, 1893; Mracek, Arch. f. Dermat. Suppl. 1893 (with literature). Lazarus-Barlow, Brit. Med. Journ. ii., 1899.

IX.—TUMOURS PROPER AND PARASITES OF THE HEART.

Primary tumours are exceedingly rare in the heart. According to Berthenson the structure in 30 published cases of primary tumours of the heart was as follows:—Sarcoma 9 (Pure Sarcoma 5, Fibrosarcoma 3, Myxosarcoma 1); Myxoma 7 (Pure Myxoma 4, Fibromyxoma 3); Fibroma 6; Syphilitic tumours 2; Cancer 3; Fatty tumour 2; Cyst 1. Rhabdomyomata have been described.

Secondary tumours are also rare. **Sarcomas** occurring in the neighbourhood may spread to the heart, and especially those of the mediastinum, involving first the parietal and then the visceral pericardium. Sometimes also a Cancer of the œsophagus extends to the pericardium. Cancers when they become generalized sometimes occur in the heart, in the form of round pale tumours (see Fig. 343).

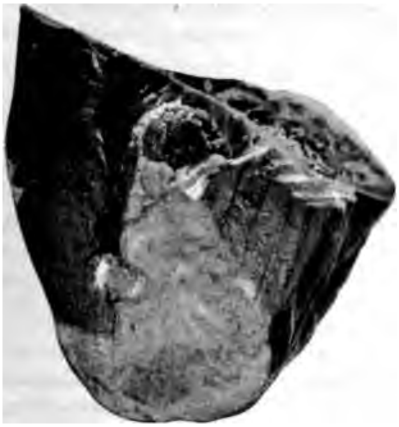


Fig. 343.—Secondary cancer of the heart. The apex is replaced by a growth which projects into the ventricle. The summit of the growth is covered with an adherent thrombus. The primary growth was in the lung.

Of **Parasites**, the echinococcus and the cysticercus cellulosæ have been found in the heart. The cysticercus of the tænia solium is frequent in the heart of swine, and that of the tænia mediocanellata in cattle, but they are very rare in man.

Literature.—Berthenson, Virch. Arch., cxxxii., 390, 1893; Fraentzel, Vorles. über die Krankh. des Herzens, 1891; Geipel, Centralb. f. allg. Path., x., 1899; Seiffert, Ziegler's Beiträge, xxvii., 1900.

SECTION II.—CONTINUED.

B.—BLOOD-VESSELS.

I. **Diseases of the Arteries.** (1) Thrombosis and Embolism. (2) Obliteration. (3) Acute inflammation. (4) Chronic endarteritis or atheroma; (*a*) Causation and nature, (*b*) tissue changes, (*c*) effects on circulation. (5) Endarteritis obliterans. (6) Retrograde changes: (*a*) fatty degeneration of the intima, (*b*) calcareous infiltration with ossification, (*c*) amyloid disease. (7) Aneurysm; (*a*) causation and mode of production; injury to middle coat and increase of blood-pressure; (*b*) coats of artery in aneurysm; (*c*) thrombi; (*d*) condition of branches; (*e*) effects on the heart; and (*f*) on parts around; (*g*) terminations, by cure, by pressure effects, by rupture. (8) Special forms of aneurysm; (*a*) cirsoid aneurysm or aneurysm by anastomosis; (*b*) traumatic aneurysm; (*c*) dissecting aneurysm; (*d*) varicose aneurysm. (9) Syphilitic and tubercular affections of arteries.

II. **Diseases of the Veins.** (1) Thrombosis. (2) Inflammations, including septic phlebitis and pyæmia. (3) Varix, causation and character of changes; Hæmorrhoids; varicocele. (4) New-formations in veins.

THE blood-vessels are to be regarded as tubes of which the essential constituent is the intima. According to circumstances the intima becomes clothed with external and middle coats, and so we have arteries and veins. We have already seen that, in nearly all new-formations, blood-vessels are produced as well as the proper tissue, and that it is first a tube composed of intima which is formed, *i.e.* a capillary. This primary vessel is capable of enlargement and further complication in the way just indicated, so that a transformation of the primary capillaries into arteries and veins may take place. This formation of vessels and their further development according to the requirements of the tissues is an exceedingly common occurrence, and may be regarded as equivalent to that which occurs in the formation of the tissues during the period of development and growth of the body as a whole. A process of a similar nature is sometimes seen when the obstruction of an artery causes the current to be in great part diverted into other channels. We know that in this case the anastomosing vessels enlarge, small arteries become converted into large ones, and perhaps even capillaries into arteries. The vascular system is thus an exceedingly plastic one, and possesses great powers of new-formation and development according to the needs of the tissues.

I.—DISEASES OF THE ARTERIES.

1. **Thrombosis and Embolism.**—These conditions having been somewhat fully discussed in previous pages, it only remains here to refer to the more local changes.

Thrombosis occurs as a secondary result of disease of the walls of arteries, chiefly in cases of atheroma and aneurysm. In the former it is often the cause of the final closure of the vessel. There is also thrombosis as a result of ligature of arteries. Acute inflammations in arteries also induce thrombosis; this is especially the case in septic inflammations. There may be in this way a condition similar to the more frequent septic thrombosis in veins (thrombo-phlebitis).

Embolism is very frequent in arteries. If the embolus be a simple one such as a piece of thrombus, the portion of artery affected will undergo a process of chronic inflammation and the plug will become organized in the manner about to be described. A septic embolus, on the other hand, will become the centre of a suppurative inflammation. We have also embolism from the penetration of tumours and parasites.

2. **Obliteration of arteries.**—In several of the affections to be considered in the succeeding paragraphs, partial or complete occlusion and obliteration of arteries occurs, and the processes, although differing somewhat in detail, have many points in common. In all of them there are usually conjoined the two processes of thrombosis and inflammation.

Obliteration by ligature affords the simplest illustration. When an artery is ligatured, the internal and middle coats are torn through, as shown in Fig. 344. In consequence of the injury and stagnation of blood thrombosis occurs, and the thrombus, which contains a considerable excess of leucocytes, extends to the nearest branch, as is well shown in Fig. 21, p. 81. This is followed by inflammatory changes affecting primarily the internal coat. This tunic becomes cellular and swollen so that it bulges inwards and impinges on the coagulum. The inflamed internal coat becomes vascularized, new-formed vessels penetrating into it from the vasa vasorum. The internal coat thus sends buds or projections inwards which replace the thrombus by vascularized granulation tissue. The new-formed vessels are produced by budding from the vessels of the external and middle coats, and these tunics also take some part in the inflammatory process, but the middle coat is much less active than the external, and its special character disappears in the process. The granulation tissue thus formed has the usual tendency to form connective tissue, and the final result is that the portion of artery concerned is resolved into a piece of connective tissue which may form part of the cicatrix of a wound.

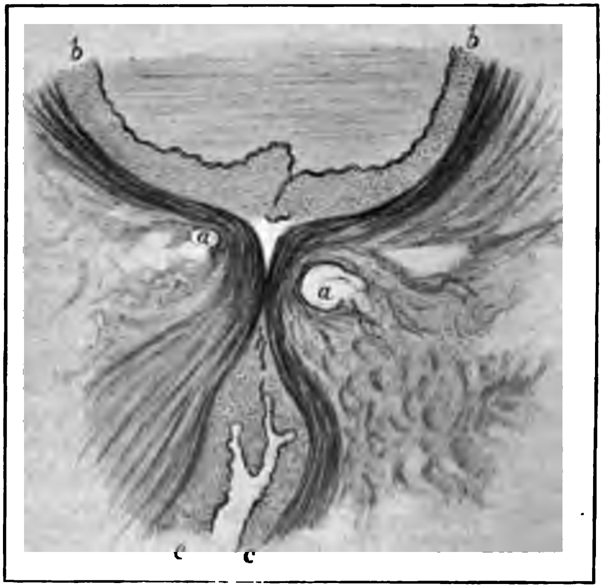


Fig. 344. Longitudinal section of an artery at the seat of ligature. *a*, *a*, apertures in which the silk ligature was found. The external coat is drawn in at this place, while the middle and internal coats are absent, being absolutely disjoined. These coats are seen above at *b* and below at *c*. × 18.

When **Arteries have been wounded** a somewhat similar process occurs. If the artery is cut across, the muscular coat by its contraction narrows the calibre of the artery and withdraws it within its sheath. The blood flowing out through the orifice deposits leucocytes, and a clot forms within the sheath and at the orifice of the vessel, by and by completely obstructing it. This coagulum will be a white thrombus. The ensuing processes will be similar to those just described. (See Fig. 21, p. 81, and Figs. 23 and 24, pp. 83, 84.)

In the case of obliteration from other causes, the process of final organization may go on in the manner described (see Fig. 345), but it is sometimes interfered with by the diseased condition of the wall of the artery or by the character of the obliterating agent. If the latter be of an irritating nature, as in septic embolism, then there can be no organization, and if the vessel wall be seriously diseased, as is often the case in atheroma, then the whole process of organization may remain absent.

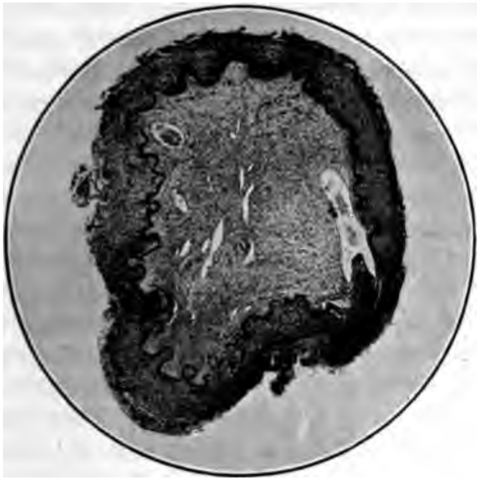


Fig. 345.—Organized thrombus in a cerebral artery. × 25.

3. **Acute inflammation of arteries. Acute arteritis.**—Arteries often take part in inflammations in their neighbourhood, but an independent acute inflammation of the walls is very rare. An endocarditis affecting the aortic or pulmonary valve sometimes extends to the neighbouring parts of the aorta or pulmonary artery, producing warty projections on the internal surface of these. More particularly, when, in acute endocarditis, a considerable thrombus forms on the aortic valve and comes against the wall of the aorta, it may lead to an acute endarteritis there.

Purulent arteritis is the result of septic inflammation in the neighbourhood, or of septic embolism. The process is similar to that in septic phlebitis.

4. **Atheroma. Chronic endarteritis.** (*Arterio-sclerosis, endarteritis deformans, endarteritis nodosa.*)—These names are applied to a disease of very frequent occurrence in arteries, the nature of which has been differently regarded at different times.

(*a*) **Causation and nature of the disease.**—According to the more common view of the process the disease is an inflammation of the internal coat, and hence the name endarteritis. But there are several indications which tend to remove atheroma from the category of a simple endarteritis. The thickening of the intima, which is the primary feature, partakes of the nature of a hypertrophy, the new tissue being more special in structure than the ordinary new-formed tissue of inflammation (see below). It is also a tissue which tends to degeneration, mostly fatty degeneration. The fact that the disease is peculiarly one of advanced life is another fact of importance, and it may also be said that a weakness of the wall of the vessel must be regarded as one of the principal agents in the causation of the disease. While there is this predisposition the actual supervention of the disease is apparently caused by mechanical irritation. Its principal seat is the arch of the aorta, and this is doubtless due to the fact that this part is more exposed to the force of the wave of blood during the systole of the heart than any other portion of the arterial system. The disease is frequently met with in the arteries of the brain, and here it is more difficult to account for its occurrence on the theory of mechanica irritation, but the atheromatous patch is often situated just at a bifurcation, where presumably, the vessel wall is more exposed to the forc of the current. It is also common, as already remarked, in the coronar arteries, where we may presume that the blood pressure is higher tha in other arteries of their size. Again, it is met with in the pulmonar artery in cases of hypertrophy of the right ventricle, the excessiv impulse of the blood from the hypertrophied ventricle apparentl determining its occurrence. As we shall see afterwards, syphilis produces a disease of arteries in some respects similar to atheroma.

(*b*) **The tissue changes.**—The disease consists in a more or les localized thickening of the internal coat. The thickening is nearl always distinctly limited in area, so that we speak of **Atheromatou patches** (hence the name *endarteritis nodosa*). When we examine th aorta in the earlier stages we see elevated areas with tolerably abrup edges, and usually of a dead white colour as compared with the su rounding intima. These patches are hard, and cut like cartilage. I the arteries of the brain the diseased parts are seen, without openi the vessels, as opaque white patches, and the vessel is more rigid tha normal, so that it does not collapse ; the calibre also is diminishe sometimes very greatly, by the inward projection of the patch. C cutting into the patch, in either the aorta or a cerebral artery, there often an opaque yellow colour revealed in the deeper parts, and this an indication of fatty degeneration. Very often, too, there is, especial in the aorta, calcareous infiltration of the deeper parts of the patc but these two conditions will be more fully discussed further on.

In considering more particularly the details of the process, it instructive to examine microscopic sections, including the edge of th patch and the neighbouring parts of the vessel. In well-preserv it cases it can be seen that the endothelium of the intima is inued over the patch, a cellular proliferation in the sub-endothelial ie is seen to be the essential feature (Fig. 346). In nearly all there is little difficulty in observing that the patch is really a kening of the internal coat, as shown in Figures 347 and 348. thickened intima is composed of a dense connective tissue, which he early stages contains many round, oval, and stellate cells. In y cases the thickened intima can be made out to present a similar cture to the normal intima. A section on the flat shows large bers of branching cells (as in Fig. 349), such as characterize the

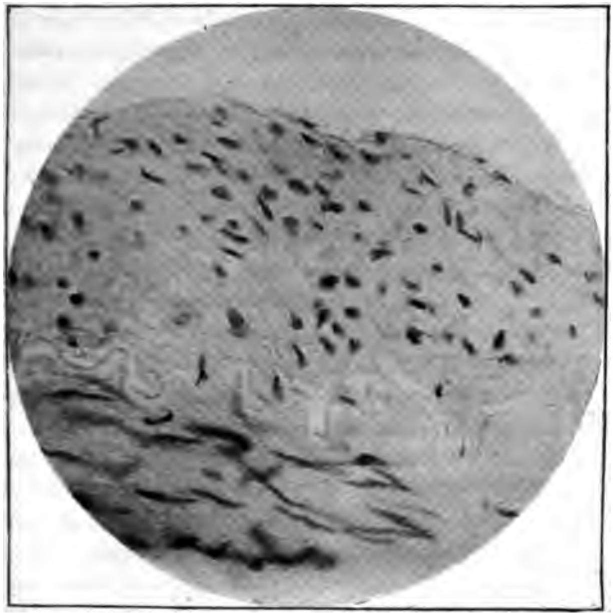


Fig. 346.—Beginnings of atheroma in a small artery. There is thickening of the intima, with abundant cell-formation. The membrane of Henle is seen as a sinuous band. × 370.

nal structure. The new-formed tissue thus constitutes a hyper-hy of the intima.

a fully formed patch the structure is often somewhat indefinite. tissue is indeed half obsolete, and, as already indicated, fatty neration readily occurs. The fatty degeneration begins usually in leeper layers of the patch, so that on cutting into it one generally in the portion of the patch bordering on the middle coat an ue yellow streak (see also Fig. 350). The fatty degeneration at first affects the cells of the intima (as shown in Fig. 350), but as goes on the intercellular substance gives way, and the tissue b

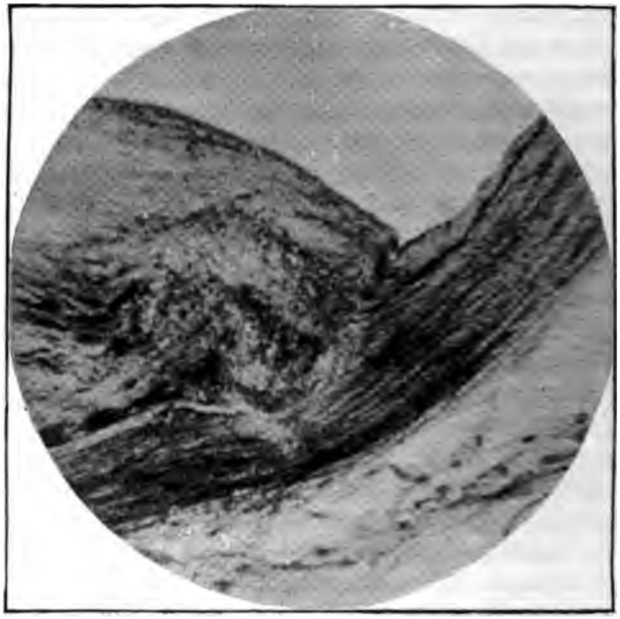


Fig. 347.—Edge of patch in atheroma of femoral artery. To the right the membrane of Henle is seen as a dark band. The patch has broken through the membran and projected itself into the middle coat. × 40.

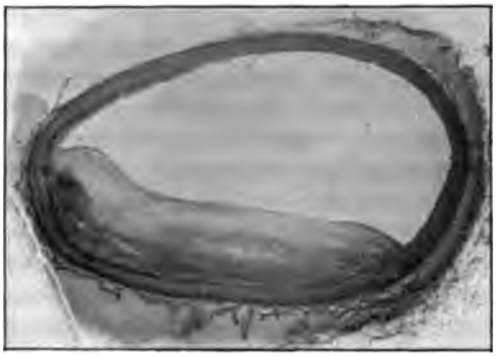


Fig. 348.—Atheroma of femoral artery. The disease consists in a localized thickening of the intima forming the atheromatous patch. × 6.

down, so that a cavity containing fatty debris with crystal margarine and of cholestearine is formed. It is from the charact this fatty debris that the name atheroma is derived, and the cavity thus formed is sometimes called an **Atheromatous abscess.** (See Fig. 351.)

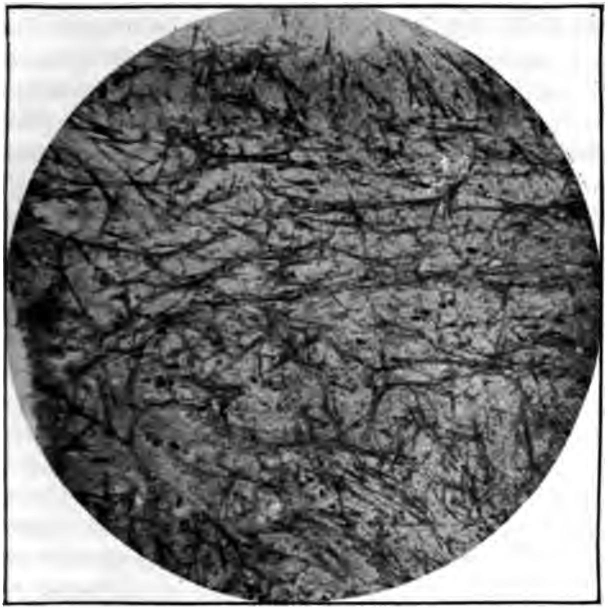


Fig. 349.—Section of atheromatous patch on the flat. It is seen to present stellate cells with elongated processes. × 350.

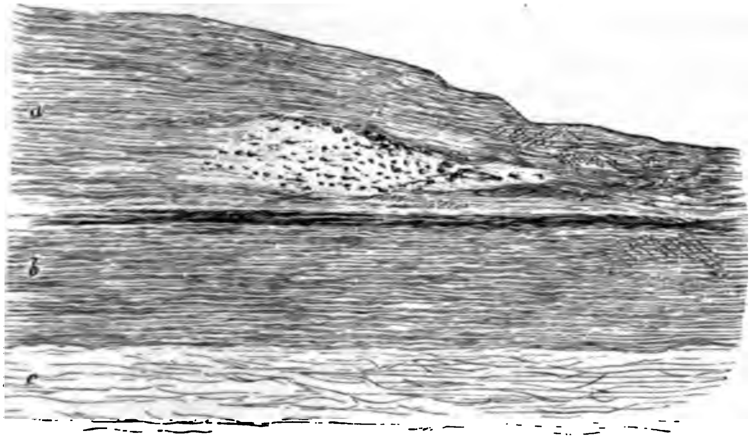


Fig. 350.—Diagrammatic sketch. Atheroma of aorta. The internal coat (*a*) is seen to be thickened. In its deeper layers there are darker markings indicating the commencement of fatty degeneration ; *b*, middle, and *c*, external coat. × 22.

The tissue superficial to the cavity may ultimately give way, and [illegible] expose the cavity, thus forming an **Atheromatous ulcer.** (See Fig. 352.) The ulcer sometimes presents calcareous masses in its walls, and in any case it may induce the deposition of fibrine on its surface.

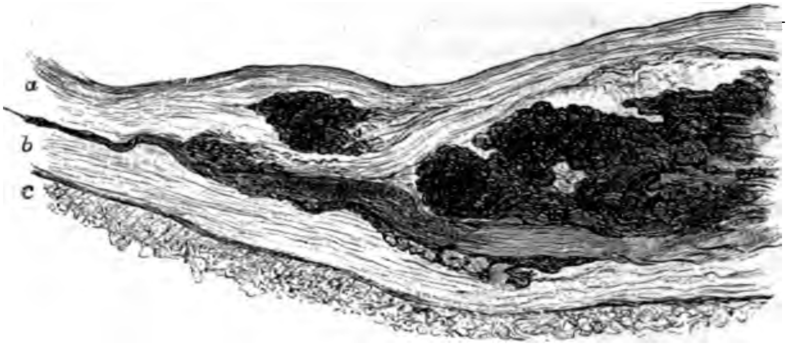


Fig. 351.—Diagrammatic sketch. Atheroma of femoral artery. The greatly thickened internal coat (*a*) is shown. In the midst of it, towards the right, are dark masses consisting mainly of fatty debris, and representing the atheromatous abscess. At one part the middle coat (*b*) is considerably encroached on from within. × 22.

Calcareous infiltration is a frequent result in the atheromatous patch. The dense tissue of the patch may become infiltrated with lime salts, with or without a preceding fatty degeneration. This is peculiarly the case when the tissue is very hard and dry. We shall see afterwards that some individuals present a very great tendency to the deposition of lime salts in the walls of their arteries, and there are cases of atheroma in which this tendency is very marked, so that with comparatively little atheromatous thickening there may be very extensive calcareous deposition. At first the salts are deposited in fine granules, and in the deeper layers of the patch, but as time goes on these aggregate into consistent masses, so that we have **Calcareous plates** of various forms and sizes, sometimes attaining to a square inch in area. These plates, having abrupt edges, not infrequently tear through the remaining layers of the intima, and present an edge or angle inside the vessel. They may even become to a considerable extent separated, and hang into the calibre attached only by a strip of intima like a hinge. The rough calcareous edge very commonly induces a deposition of fibrine, and the thrombus thus formed may subsequently become detached, and form an embolus. The determination of the preponderance of the fatty or calcareous change appears to depend on individual peculiarities. Both forms are very frequent in the aorta. The fatty change preponderates greatly in the cerebral arteries. The aorta is sometimes greatly

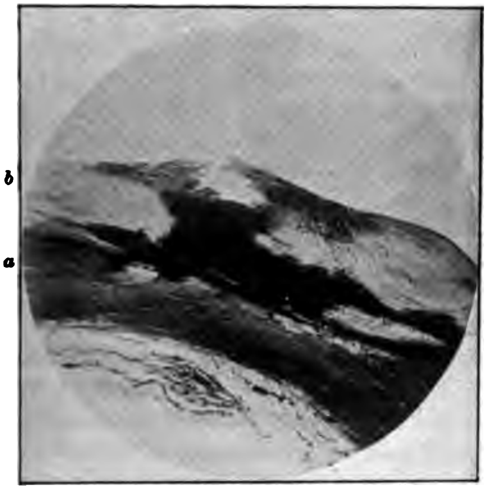


Fig. 352.—Atheroma of aorta: *a*, middle coat; *b*, atheromatous internal coat. There is a marked opacity of the intima in its deeper parts from fatty degeneration, and it impinges on the media. The fatty structure has come to the surface and caused an atheromatous ulcer. × 8.

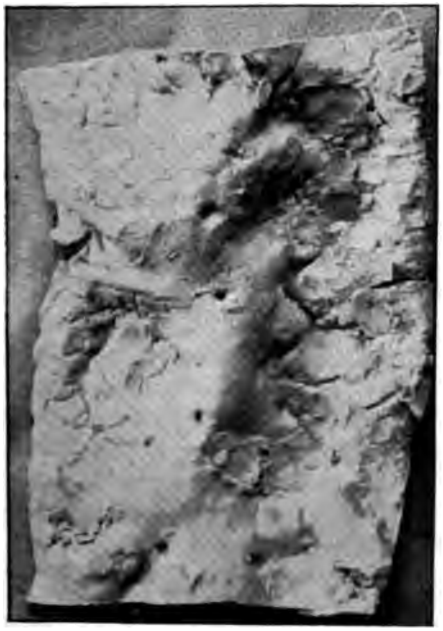


Fig. 353.—Portion of thoracic aorta, almost continuously atheromatous, and with many calcareous plates.

altered by the atheroma and calcareous deposition, as shown in Fig. 353.

Besides these, which may be regarded as the primary lesions of atheroma, there are frequently present certain further changes which have been variously interpreted as parts of the primary lesion or as **Secondary results**. These concern chiefly the **media** and the **adventitia**. There is no doubt that in atheroma of the aorta there are very commonly inflammatory manifestations in the two outer coats, and some authors have regarded this as an indication that the atheroma is merely part of a general inflammation of the vessel-wall. But these manifestations are usually absent in atheroma of the smaller vessels, and may be wanting in the aorta itself. They are either the result of the atheroma, or else they are conditioned by those changes in the circulation (increased pressure) which we have seen to take part in the causation of atheroma.

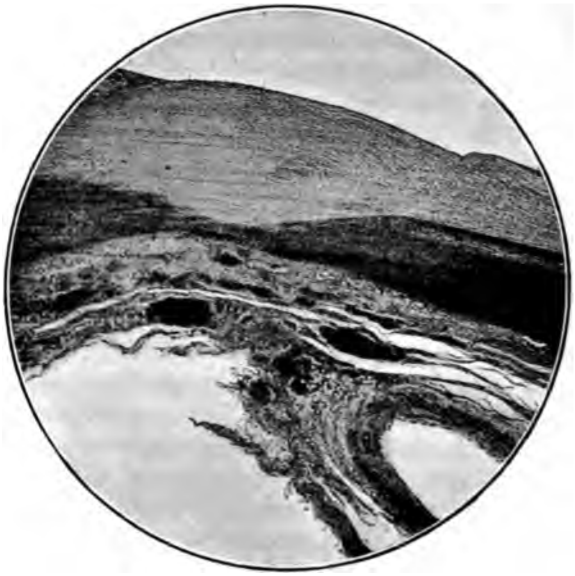


Fig. 354.—Atheroma of aorta. Underlying the thickened intima the markedly atrophied media is shown. × 15.

The atheromatous patch, forming a hard nodule, impinges on the media, and not infrequently seriously interferes with it. There may be thinning of the media from within (see Fig. 354), along with fatty changes which may manifest themselves in the muscle cells of this coat (see Fig. 355). There may be, on the other hand, traumatic lesions, *sometimes* resulting in rupture of the elastic lamina of Henle. This injury and rupture brings about a process of repair, so that we have the usual formation of vascular inflammatory tissue in the media going on to cicatrization. Moreover, the atheromatous patch is largely in the condition of a piece of dead or obsolete tissue, and, on the principles already expounded, it is liable to be eaten into and replaced by vascular tissue. The deeper parts of the patch are frequently thus vascularized, especially when the media has been injured. These are true inflammatory changes in the intima, and are different from the atheromatous process. They are often continuous with the similar changes in the media and adventitia. These lesions are of importance in relation to the causation of aneurysms (see further on).

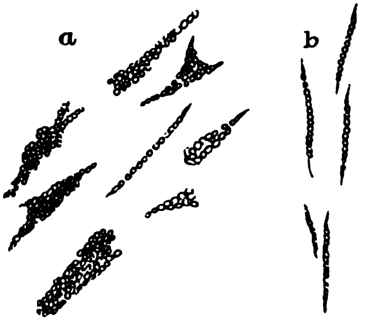


Fig. 355.—Fatty degeneration in atheroma: *a*, from internal coat; *b*, muscle cells from middle coat. × 350.

(c) **Effects of atheroma on the circulation.**—There are four alterations which it produces, each of which may, according to circumstances, have important effects on the circulation. The disease causes *narrowing of the calibre*, *interference with the muscular contractility*, *rigidity*, and *sometimes actual injury* to the wall.

The **Narrowing of the vessel** will be of little consequence in such large arteries as the aorta, but in the case of the cerebral vessels, the coronary arteries of the heart, and the arteries of the legs, the interference with the circulation may be considerable (see Figs. 356, 357). We have seen this illustrated in the case of the coronary arteries of the heart, especially when thrombosis supervenes, where the disturbance of the circulation sometimes produces severe angina, and may lead to sudden death, and it is no less potent as a cause of disease in the cerebral arteries.

The **Interference with the contractility** will also affect mainly the arteries of smaller dimensions, and in the case of the arteries of the brain, the absence of that control of the circulation which is afforded by their varying calibre may lead to serious consequences.

Rigidity and weakening of the wall are very important consequences of atheroma, especially in the aorta, where they are important factors in the causation of aneurysm. The immediate consequence of rigidity of the aorta is that during the systole of the heart the vessel does not dilate, and at the end of the systole it does not recoil, so that the force of the elastic recoil is lost to the circulation, and in distant parts there is apt to be more or less stagnation. As a result of this we have hypertrophy of the left ventricle, which is often very marked in cases where much calcareous infiltration exists. The hypertrophied ventricle sending the blood forcibly into the rigid aorta produces com

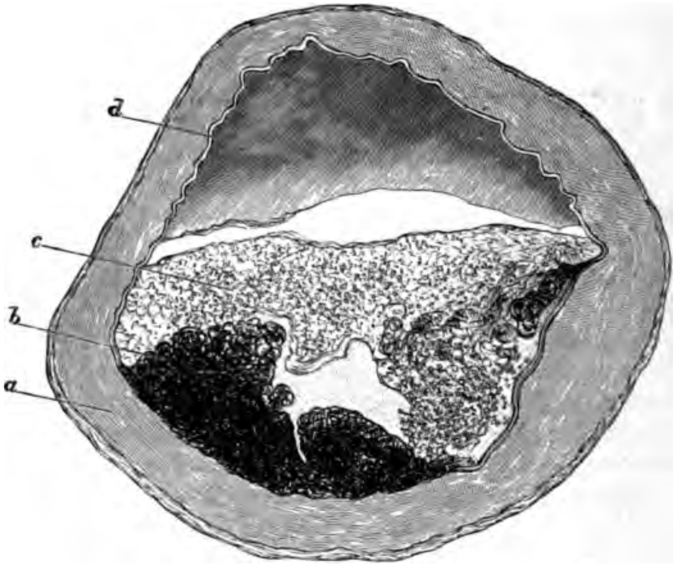


Fig. 356. Diagrammatic sketch. Atheroma of cerebral artery. The greatly thickened internal coat (*a*) is seen. In its substance are dark masses (*b*) in which margarine crystals were found. On the surface is a paler layer (*c*) consisting of partially organized thrombus; (*d*) blood occupying the remaining calibre. × 34.

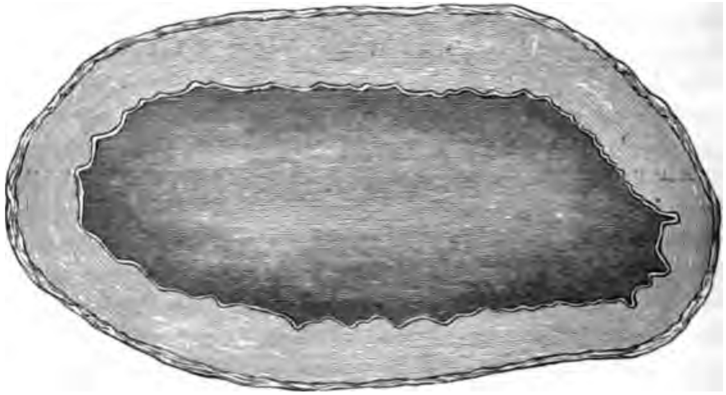


Fig. 357. Diagrammatic sketch. Transverse section of a normal cerebral artery to contrast with Fig. 356. × 34.

monly a diffuse dilatation of the arch. The influence of atheroma in producing aneurysm will be considered subsequently.

The time of life at which atheroma is most frequent is a point of some importance in relation to the causation of aneurysm. According to Rokitansky, it is commonest between the ages of forty and sixty. It is still pretty frequent down to thirty years of age, but rapidly diminishes in frequency from that age downwards. It is extremely rare under twenty years, and when it does occur it is mostly in connection with congenital anomalies of the great vessels or heart, such as stenosis of a main stem with defect of the septum, etc.

5. **Endarteritis obliterans.**—This is not an independent disease, but is frequently of considerable importance as a part of the phenomena of other conditions. It affects the finer vessels of certain organs, and consists, like atheroma, in a thickening of the internal coat (see Fig. 358) which, in these fine arteries, frequently leads to complete obliteration. This form of lesion is seen especially in interstitial inflammations of organs, and is particularly frequent in chronic interstitial nephritis, where it will be again referred to.

6. **Retrograde changes in arteries.**—We have already alluded to retrograde changes in connection with atheroma. Some more independent forms have still to be considered.

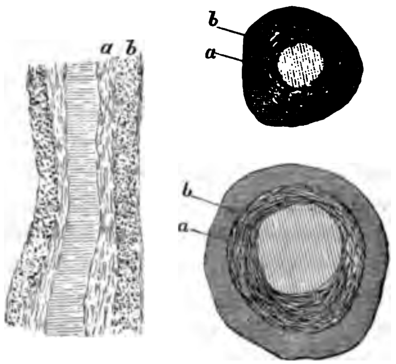


Fig. 358.—Diagrammatic sketch. Endarteritis obliterans in arteries of kidney: *a*, thickened and fibrous internal coat; *b*, middle coat.

(*a*) **Fatty degeneration of the intima of arteries.**—This condition is apt to be mistaken for atheroma. We frequently see, especially in the aorta, yellow markings slightly raised above the internal surface, and having the appearance of superficial figurings. They are to be found in the aorta, pulmonary artery, and other parts of the arterial system. If a portion of such a patch be examined under the microscope by removing a thin layer by a section parallel to the surface, it will be found that the condition consists in a fatty degeneration of the cells of the intima. The flat branched cells are demarcated by the presence in them of abundant fat drops. If the fatty degeneration is much advanced then the intercellular substance becomes also the seat of fat drops, and the cells are no longer demarcated. It sometimes happens that when the degeneration is very advanced the little patch softens and an erosion forms. This erosion is very superficial, and is not to be mistaken for the atheromatous ulcer.

This condition is sometimes met with in the bodies of comparatively healthy persons; we have already seen that in anæmic and emaciated persons it is frequent, and it is to be classed in the same category as fatty degeneration of the muscular tissue of the heart.

(*b*) **Calcareous infiltration of arteries.**—We have already seen that in atheroma there is very frequently a calcareous infiltration of the affected structures, and it has been stated that individual peculiarities appear to play an important part here. In some cases a more independent calcareous deposition occurs, and here individual peculiarities are of still greater consequence. Calcification of the middle coat is the most frequent and important form. This is very frequently associated with atheroma, but it is noteworthy that the atheroma and calcareous deposition very often affect different arteries or different parts of the same artery. We may have, for instance, atheroma of the aorta and calcification of the middle coat in the femoral and smaller vessels; or there may be atheroma as well as calcification in the femoral, but in their extreme degrees the two are present at separate parts of the artery. For instance, Fig. 351, p. 550, and Fig. 360 are from the same femoral artery, and from parts near each other; but the one shows atheroma with fatty degeneration, while the other exhibits very advanced calcareous infiltration of the middle coat. It may here be remarked that calcification affects by preference the arteries of medium and smaller size. It is often very pronounced in the femoral and brachial, and extends to those of smaller size, but not to the finest arteries.

The deposition occurs in most cases primarily into the muscular fibre-cells of the middle coat, and at first marks these out by the presence of fine opaque granules (see Fig. 359), but the author has met with case in which the elastic lamina of Henle was the primary seat of deposition. The granules flow together till a patch is formed of an opaque appearance, but confined to the middle coat. As the calcareous deposition increases, the patch sometimes assumes a crystalline appearance, and the material may become broken and irregular, as in Fig. 360. This condition necessarily gives greatly increased rigidity to the walls of the arteries, and the feeling of rigidity so often felt in the radial and other smaller arteries is mostly due to this cause, and not to atheroma. The fact, however, that calcification of the middle coat is so often associated with atheroma renders this rigidity to some extent an indication of the existence of atheroma in the larger arteries. To the naked eye the calcified parts frequently manifest themselves by the appearance of a circular opaque striation, visible especially when the artery is laid open and viewed from within. The appearance is better seen if the artery be allowed to dry partially, as then the normal tissue becomes more transparent and the chalky structures more prominent. In that case complete or partial rings are seen, not unlike the irregular cartilaginous rings of the bronchi, but smaller. Another method of rendering the calcification prominent is to tear off the internal coat, which is usually somewhat loosely attached.

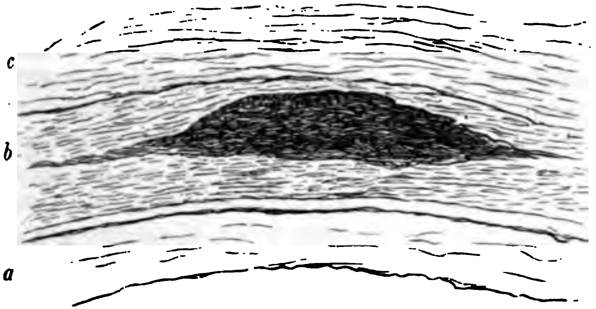


Fig. 359.—Diagrammatic sketch. Calcareous infiltration of the middle coat (*b*) in an artery, early stage, with atheroma (*a*). At the edge of the affected part, the general outline of the muscle fibre cells can be made out. × 60.

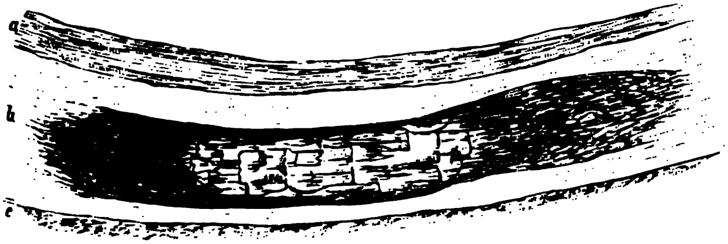


Fig. 360.—Diagrammatic sketch. Calcareous infiltration of the middle coat of an artery. The lime salts have aggregated together so as to produce a crystalline appearance. This was taken from the same artery as Fig. 351. × 22.

The calcified middle coat sometimes undergoes a true **Ossification**, so that spicula of bone may be mixed with calcareous masses. The ossification is secondary to the calcareous infiltration, and is always small in extent compared with the latter. It is really the result of a chronic inflammation around the calcareous masses, the new-formed connective tissue, penetrating amongst these, becoming transformed into true bone by reason of the rigidity of the structures and the abundance of lime salts.

The author has observed a similar development of true bone in a collapsed hydatid cyst in the liver. In this case the new-formed connective tissue had penetrated amongst the degenerated products of the parasite, and in some parts had developed osseous tissue with regular lacunæ and canaliculi.

The calcareous infiltration of the middle coat renders the artery peculiarly rigid, and, when extensive, induces hypertrophy of the left ventricle just as rigidity of the aorta does. The rigid vessels are also liable to dilatation, as in the case of the aorta. But besides that, the calcified middle coat is brittle, and affords a much less effective resistance to the distensile wave of blood. An additional strain on the circulation, or some special movement of the body, may break the brittle coat and directly lead to aneurysmal dilatation of the artery. It is not unlikely that peripheral aneurysms are frequently induced in this way, and especially those of the popliteal region, where the artery is peculiarly liable to mechanical injury from the movements of the limb.

A peculiar **Calcification of arteries by metastasis** has been described. We have already seen that when great destruction of bone is occurring the lime salts may be deposited in distant parts, the lungs and mucous membrane of the alimentary canal being the chief seats. Kuttner has described a case in which the incrustation occurred in the arteries. The deposition increased in amount the further removed the arteries were from the heart, and it was especially manifest where the current was permanently impeded, as where a small branch issued from a comparatively large stem. In this case it was the intima that was incrusted, and it was peculiar that the veins were not in the least affected. Apart from the incrustation, the arterial coats were apparently normal. The source of the lime salts was an acute caries of the vertebral column from the first dorsal to the last lumbar. In relation to the pathology of the case, it is to be added that there was a purulent interstitial nephritis, so that the excretion of lime salts was presumably impeded. It is remarkable that in this case the metastasis was to the arteries, and that the lungs and the mucous membrane of the intestine were entirely free.

(c) **Amyloid disease.**—This is frequent in the walls of arteries in various organs. (See p. 400, and under Kidneys, Spleen, Liver.)

7. **Aneurysms.**—An aneurysm is a localized dilatation of an artery. Taking this as the definition, it will follow that in the aneurysm the coats of the artery are stretched, and, to some extent, retained as the covering of it. We shall afterwards see that there are aneurysms in which this is hardly the case, in which the coats rather give way and rupture. Such aneurysms are often designated **Spurious aneurysms**, of which it will be necessary afterwards to describe several varieties. Even of the aneurysms which come under the above definition there are several varieties, but we have to consider here, in the first place, those which arise by a limited dilatation of an artery. The artery may be dilated in a considerable part or the whole of its circumference, thus forming a spindle-shaped or **Fusiform aneurysm**. The dilatation may affect such a considerable portion of a vessel as scarcely to come under the designation of an aneurysm. This is especially the case in the aorta where **Dilatation of the arch** (as in Fig. 361) is not infrequent. On the other hand, the dilatation may be such as to form a pouch, and we have then a **Sacculated aneurysm**.

Causation and Mode of Production.—A general survey of the ions under which aneurysms occur leads to the conclusion that ief agents have to do with their production, namely, some con- which weakens or injures the wall of the vessel, more especially dle coat, and increase of the blood-pressure. The injury to the is local, the increase of blood-pressure is in the general arterial and depends on general circumstances.

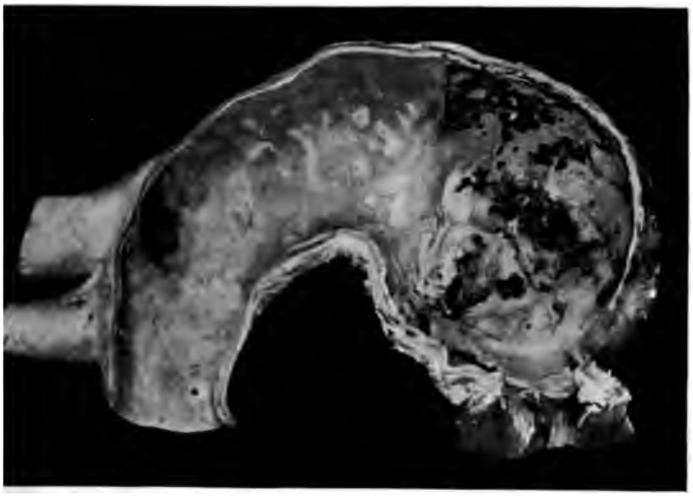


Fig. 361.—Dilatation of aorta. The vessel is shown laid open from the valve wards. There is much thinning of the wall, which is atheromatous and calcified.

heroma is to be mentioned as the most potent local agent in the ction of aneurysm. The connection of atheroma and aneurysm is ce indicated by the fact that virtually in all cases of aneurysm of orta, atheroma is present, and often in a very marked form. The er in which atheroma conduces to the causation of aneurysm has made the subject of study by the author in association with Dr. It may be remarked that, for purposes of resistance to the force e blood, the **media is the essential part of the vessel-wall.** In orta it forms a thick mantle composed chiefly of elastic and muscular es. The intima is a thin layer, and the adventitia, which is com- d of connective and elastic tissue, has neither the resistance nor the ic recoil of the media.

he relations of atheroma and aneurysm are best studied in instances re there are the first beginnings in small depressions or pouches le in scanning the internal surface. In most cases of actual rysm, and in some cases of atheroma without aneurysm, such small gs are visible. When such small depressions are examined in pic section the conditions visible are those shown in Fig. 362. will be noted, the depression coincides with an atheromatous r node. The depression is largely at the expense of the middle hich tapers off towards the centre, and is entirely awanting at oint near the bottom of the depression. The actual dilatation is ntly referable to **destruction of the media,** and this has been ioned by the impingement of the patch or node upon it. It has

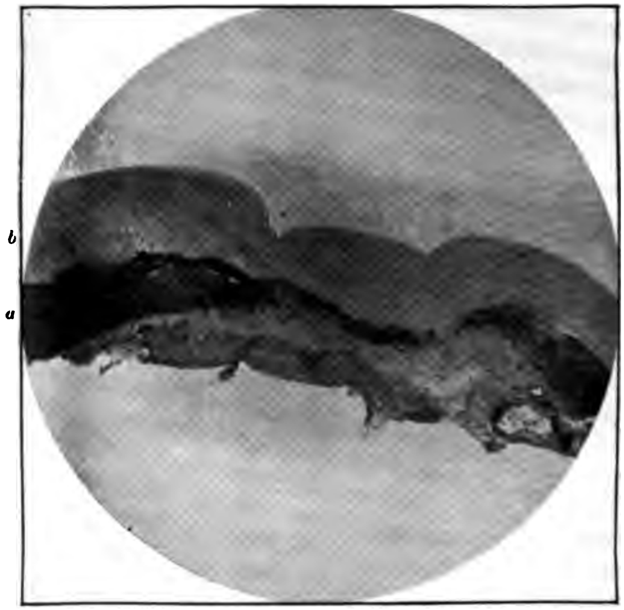


Fig. 362.—Beginnings of an aneurysm in the aorta. *a*, Media; *b*, intima. The intima is greatly thickened by atheroma, and has impinged on the media, causing great atrophy of the latter. × 8.

een already explained under atheroma that the patch often leads to njury and rupture of the media, and in the beginnings of aneurysms his is regularly present.

We have already seen also, under atheroma, that the injury to the nedia leads secondarily to inflammatory processes in the wall generally. hese are partly reparatory and are continued after the formation of he aneurysm, the wall of which, as will appear afterwards, is ultimately omposed of connective tissue formed by a process of inflammation.

Whilst atheroma is a frequent element in the causation, **other condi-ions which injure or rupture the middle coat** are also causes. Thus embolism in the cerebral arteries, when it does not cause complete obstruction, is liable to produce aneurysm by injuring the wall. Examination of an aneurysm of this kind showed that there was virtually a gap in the middle coat, the intima and adventitia being pushed outwards. Calcification of the media, by rendering it brittle, may also be regarded as an agent in the causation of aneurysms. In Fig. 363 is represented the opening of a small aneurysm of the aorta which bulged into the infundibulum of the right ventricle. It originated at the junction of two of the aortic cusps, which were thickened and calcified as the result of chronic endocarditis. A blow over a vessel may extend deeply enough to injure its coats, or the fractured end of a bone may do so. (See under Traumatic Aneurysm.)

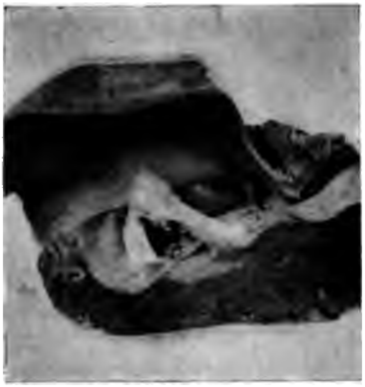


Fig. 363.—Small aneurysm of the aorta originating at the junction of two of the aortic cusps.

The influence of **Increase of blood-pressure** is shown by a number of considerations. In severe continued exertion we find the most frequent cause of increased blood-pressure. The blacksmith who has to manipulate a piece of hot iron while wielding a heavy hammer, or the football player who has a succession of fast runs to make, or the mountaineer who forces the pace too much, or the soldier who has to perform long marches with heavy accoutrements, must each put a strain on his heart and larger vessels which ordinary persons are not liable to. In this connection the **Age** at which aneurysms are most common is of importance. This coincides with the latter part of the most active period of life. Aneurysms are most frequent between the ages of thirty and forty. On the other hand, atheroma, although not infrequent between these ages, is much more common after forty. It will be seen that aneurysms coincide with the time of life when the period of greatest bodily vigour overlaps the beginnings of the period of occurrence of atherom Another circumstance is the great preponderance of aneurysm in th **male sex.** Atheroma shows a similar predominance, but not nearly t such an extent. As has been pointed out by M'Crorie, statistic bearing on this point are not usually reliable, unless it be remembere that males are more frequently subjected to post-mortem examinatio than females. But still when the differences are very great th factor cannot be the determining one. Thus Bizot found in 189 cas of aneurysm 171 in males and 18 in females, and Hodgson found in cases 56 in males and 7 in females. The explanation of this differen is chiefly that men are more exposed to extremes of physical exerti than are women. On the same principle we explain the greater fr quency of aneurysm in some countries as compared with others. Th excessive stress to which workmen in our engineering and shipbuildi establishments and sailors in our ships are frequently put in th country goes far to explain the frequency of aneurysm here.

Another circumstance of importance is the **Localization of aneurys** in different arteries. Nearly half the cases of aneurysm occur in t aorta, and the great majority of these in the thoracic portion. W have seen that atheroma is most frequent in this vessel, but, in additi to that, the aorta is most exposed to the **excessive pressure of t** blood when the heart is stimulated to unduly forcible action. Next the aorta the popliteal artery is most frequently the seat of aneurys It has already been pointed out that this vessel is especially liable injury from sudden flexures of the leg, especially when the middle co is rendered brittle by calcareous infiltration. But besides that, t vessel is so situated as to be liable to localized increase of bloo pressure. As it issues from the popliteal space the artery pas between the two heads of the gastrocnemius, and is liable to constri tion by the contraction of the muscle. On this principle has be explained the frequency of popliteal aneurysm in flunkies who principal occupation is to exercise their gastrocnemii in standin But apart from that, when a person makes a severe exertion in standing posture, the gastrocnemii contract vigorously, thus pr ducing a partial obstruction of the artery and an increase of pressu above the obstructed part, while the general blood-pressure is al increased.

The following table from Crisp gives a statement of the frequen of aneurysms in different situations. It is to be observed, howev that it greatly under-estimates the number of aneurysms of t cerebral arteries, and also those of the pulmonary artery in phthi ***pulmonalis*:**

FREQUENCY OF ANEURYSMS.

	551 Cases in English Records.	364 from London Museums.
Aorta thoracica (including arch), - - -	175	207
„ abdominalis (and main branches), -	59	46
Art. pulmonalis, - - - - - - -	2	2
„ iliaca com., - - - - - - -	2	2
„ iliaca int., - - - - - - -	0	1
„ iliaca ext., - - - - - - -	9	7
„ glutea, - - - - - - - -	2	0
„ cruralis, - - - - - - -	66	12
„ poplitea, - - - - - - -	137	50
„ tibialis postica, - - - - - -	2	2
„ innominata, - - - - - - -	20	3
„ carotis, - - - - - - -	25	9
„ cerebralis, - - - - - - -	7	1
„ temporalis, - - - - - - -	1	0
„ ophthalmica, - - - - - -	1	0
„ vertebralis, - - - - - - -	0	1
„ subclavia, - - - - - - -	23	12
„ axillaris, - - - - - - -	18	8
„ subscapularis, - - - - - -	1	0
„ brachialis, - - - - - - -	1	0
„ radialis, - - - - - - -	0	1

(*b*) **The Coats of the artery in aneurysms.**—An aneurysm begins as a localized dilatation or as a little pouching of a limited portion of the artery. In the former case we have the commencement of a fusiform, and in the latter case that of a sacculated aneurysm. The little pouch which forms the commencement of a sacculated aneurysm gradually enlarges, and while its opening remains small, it enlarges outwards in all directions into a distinct sac. The walls of the sac are sometimes folded back around the aperture so as to apply themselves to the external surface of the artery, and these may become mutually adherent. In that case the aperture has a sharp edge, and it appears as if the wall of the artery were folded over so as to form the wall of the aneurysm.

The Internal coat enters variously into the constitution of the aneurysmal wall. In the case of a fusiform aneurysm it is continuous over the internal surface, and probably presents very marked atheromatous changes. In the sacculated form it is usually to be traced some little distance from the edge of the aperture on the wall of the aneurysm, and even in the midst of the internal surface of the sac portions of internal coat, greatly altered as a rule, may be discovered.

The Middle coat, as we have seen, undergoes atrophy in sacculated aneurysms. Even in fusiform aneurysms it is often difficult to the middle coat far from the beginning of the dilatation.

The External coat, on the other hand, may be regarded as fo the chief constituent of the sac. We have already seen that a very commencement of a sacculated aneurysm inflammatory formation occurs in the wall of the vessel, the vascular tissue chiefly derived from the external coat. As dilatation proceed new-formation of tissue goes on, so that the sac does not neces undergo thinning as it enlarges. The connective tissue of the ex

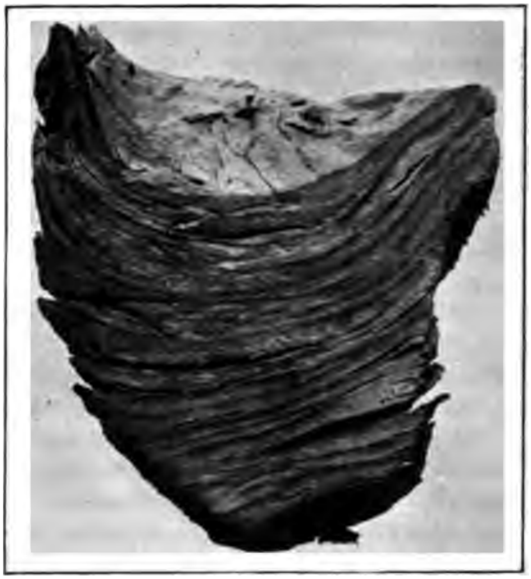


Fig. 364.—Portion of a thrombus from an aortic aneurysm showing stratification.

coat usually makes common cause with that of neighbouring struc and so the aneurysm acquires adhesions, and the surrounding stru come to form, to a certain extent, constituents of the sac.

(*c*) **Thrombi in aneurysms.**—Blood-clots are of nearly co occurrence in aneurysms, and they may almost be regarded as stituents of the sac. They doubtless aid to a great exte preventing rupture. Coagula are most frequent and most imp in sacculated aneurysms. We meet with them in the form of dry layers, which present a distinct stratification, generally p to the wall of the aneurysm (see Fig. 364). The coagula often a kind of sac inside the proper sac, and after removal retai shape of the aneurysm. The coagula are primarily **White th**

The white blood-corpuscles adhere to the rough internal wall of the aneurysm, and after they have accumulated to some extent coagulation occurs and a thrombus is formed. This process is repeated, and the formation of fibrine is thus in successive layers. Not infrequently the layers become partially separated, and the blood insinuates itself between them. A layer of whole blood is thus formed, and when it coagulates we have a red thrombus mixed with the white. As time goes on the clots become firmer, dryer, and more stringy. The layers next the sac are often of a pearly whiteness, and may be taken for connective tissue. Under the microscope, however, they are seen to be devoid of definite structure, and acetic acid brings out no elongated nuclei as in the case of connective tissue. There seems little tendency to the organization of these coagula unless the whole aneurysm becomes filled and its cavity obliterated by them. The continual distension of the cavity seems to interfere with the process of organization; but, if the cavity be obliterated by the formation of clots, then organization proceeds, as in the case of thrombosis in an artery, and by and by the aneurysm is converted into a connective tissue nodule which contracts more and more.

(*d*) **The condition of branches** given off at the seat of an aneurysm is a matter of great importance. These vessels are frequently obstructed, and there are various ways in which this may come about. The atheromatous process may occur to such an extent around the orifice of a branch as to narrow or even obliterate it. This is most frequent in small arteries like the intercostals, but is not uncommon in larger branches. Again the coagula may come to overlie the aperture, already narrowed, it may be, by atheroma. Further, it will be apparent that, as an aneurysm enlarges, especially a sacculated one, it will often drag on and contort vessels whose apertures are in or near its walls. The aperture may thus be reduced to a fissure, and the edge may be so placed as to valve the aperture. This is particularly the case in the sacculated aneurysms of the arch of the aorta (see Fig. 365). Sometimes by the enlargement of an aneurysm the aperture of the branch is to be found at the summit of the aneurysm. In that case the aperture may be obstructed in one of the ways already described, but it not infrequently remains at least partially free. The coagula may even be tunnelled in order to allow the current to flow into the branches (see Fig. 366). Another mode of closure is by the pressure of the aneurysm itself on the branch beyond its aperture. If a branch be closed in any of these ways it becomes the seat of a thrombus, and in the usual way becomes converted into a solid cord. In regard to the condition of branches it is to be observed that the aneurysm may, as it were, be continued into the branch, the first part of the latter being dilated along with the aneurysm.

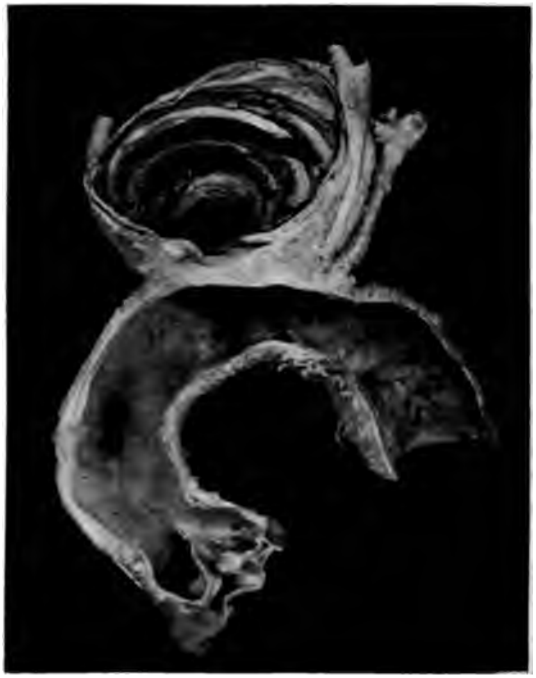


Fig. 365.—Completely healed aneurysm of the arch of the aorta. The vessels arising from arch were much narrowed at their origin.

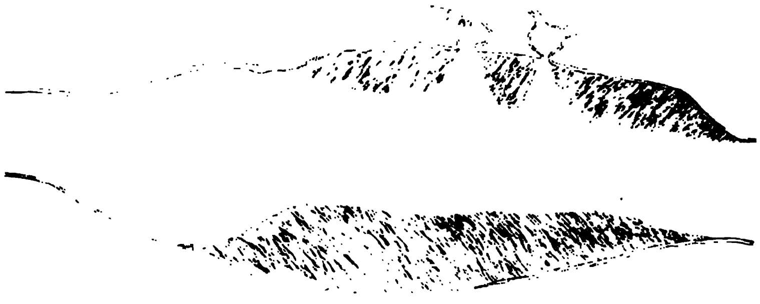


Fig. 366.—Diagrammatic sketch. Aneurysm of the abdominal aorta with clots tunnelled so as to allow the blood to reach the branches. The general lie of the stratification of the clots is shown. The cœliac axis and superior mesenteric artery are seen to be narrowed at their orifices. The posterior wall of the aneurysm is absent where it impinged against the vertebræ. Half the natural size.

(*e*) Effects on the heart.—Aneurysms affect the heart somewha *variously.* The organ is frequently depressed by the mere presenc of the aneurysm at its base. Room must be afforded for the increasing tumour, and as the position of the aorta forbids much movement upwards, the heart is pushed somewhat downwards. The extent of displacement will, of course, depend on the position and size of the aneurysm. In Fig. 367 is shown a small aneurysm of the first part of the aorta which had exercised pressure upon the coronary artery. Besides this, the heart often undergoes enlargement, especially the left ventricle. It is clear that in distending the aneurysm a considerable amount of the force of the left ventricle is wasted, and on principles already considered the ventricle must act more powerfully; the hypertrophy is therefore compensatory.

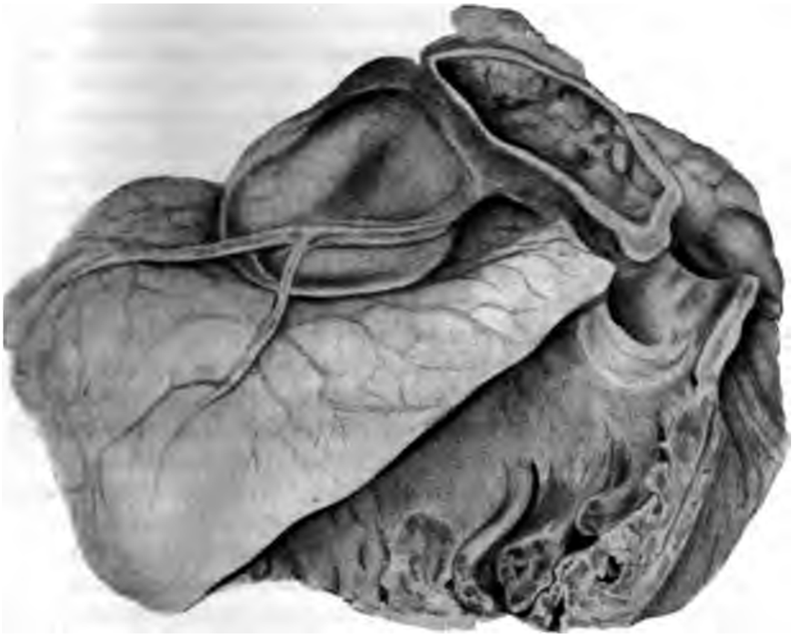


Fig. 367.—Small aneurysm of the first part of the aorta. The flattened coronary artery is shown crossing the sac.

(*f*) **Effects on parts around.**—The effects of the aneurysm on other parts will depend on the amount of pressure exercised, and the nature of the structures involved. An aneurysm often **presses on nerves**, causing primarily irritation of them and sometimes ultimately interruption and consequent loss of function. Thus aneurysms often produce violent pains, and even symptoms of angina pectoris when the nerves of the heart are pressed on. By irritation of the recurrent laryngeal nerve they may cause spasm of the laryngeal muscles, or by destroying the nerve lead to their paralysis. The **various canals within the chest**—the trachea, bronchi, œsophagus, veins—are often narrowed or completely obstructed, so that a great variety of symptoms is produced. When an aneurysm meets with a firm structure such as bone, it erodes it, as we have already seen. Cartilage resists more than bone, and in the case of an aneurysm coming against the vertebræ, we often find the bodies of the vertebræ deeply eroded, while the intervertebral cartilages stand prominently out between them (see Fig. 368). We may find also in an aneurysm advancing to the front of the chest the sternum and osseous ribs much eroded, while the cartilaginous ribs, almost isolated, are very little destroyed. In these cases it will be seen that as the dense structures are exposed inside the aneurysm, the proper wall of the latter is, by so much, deficient, and the sac of the aneurysm joins on to the bone round the edges of the eroded portion.

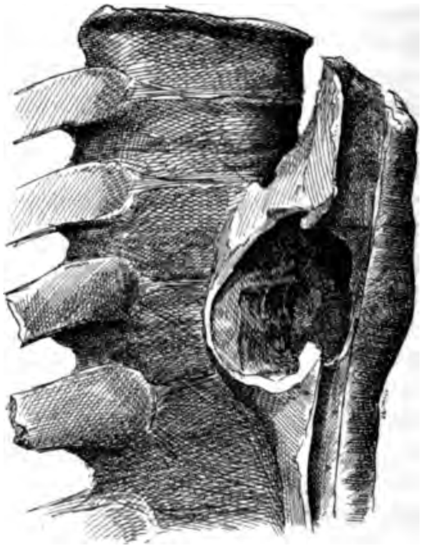


Fig. 368.—Aneurysm of aorta eroding vertebræ. The intervertebral cartilages are seen to remain prominent.

(*g*) **Terminations of aneurysms.**—Aneurysms have somewhat various terminations, much the commonest being unfortunate. Sometimes, although rarely, a cure results. This takes place only when the aneurysm becomes completely filled with thrombus (see Figs. 365, 369, 370, 371), in which case organization of the thrombus occurs with *subsequent* conversion of the aneurysm into a solid nodule of connective tissue. The formation of thrombi is brought about or encouraged in various ways. By acupuncture the internal surface may

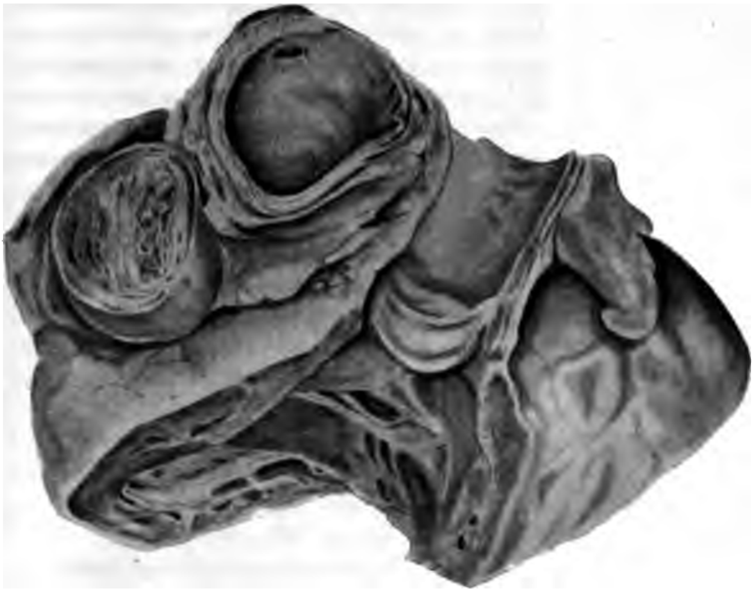


Fig. 369.—Small aneurysm of the first part of the aorta. The sac is completely filled with firm stratified thrombus. At the upper part of the figure the opening of another smaller aneurysm is shown.

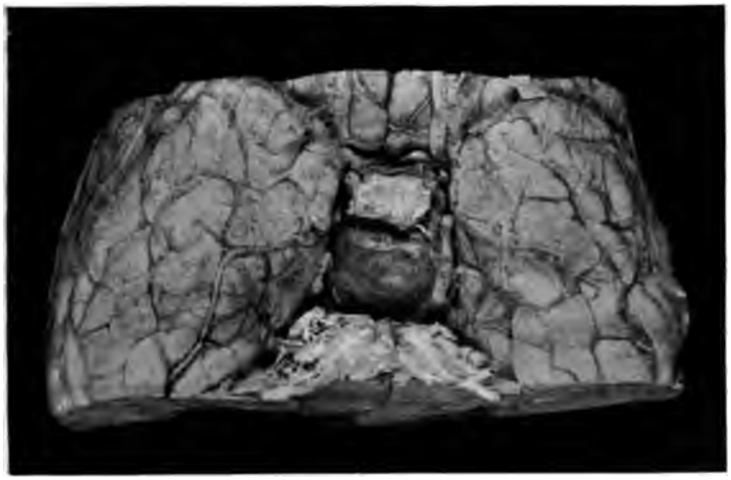


Fig. 370.—Unusually large healed aneurysm of the left internal carotid artery. The sac completely filled with thrombus occupies the middle line causing marked displacement of neighbouring structures. The pituitary body is shown on the summit of the sac.

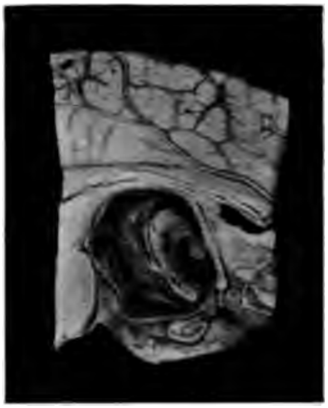


Fig. 371. —Healed aneurysm of left internal carotid artery. A section has been made through the aneurysm (see previous figure). Immediately in front of the pituitary body the internal carotid artery is seen. The sac is completely filled with firm laminated thrombus.

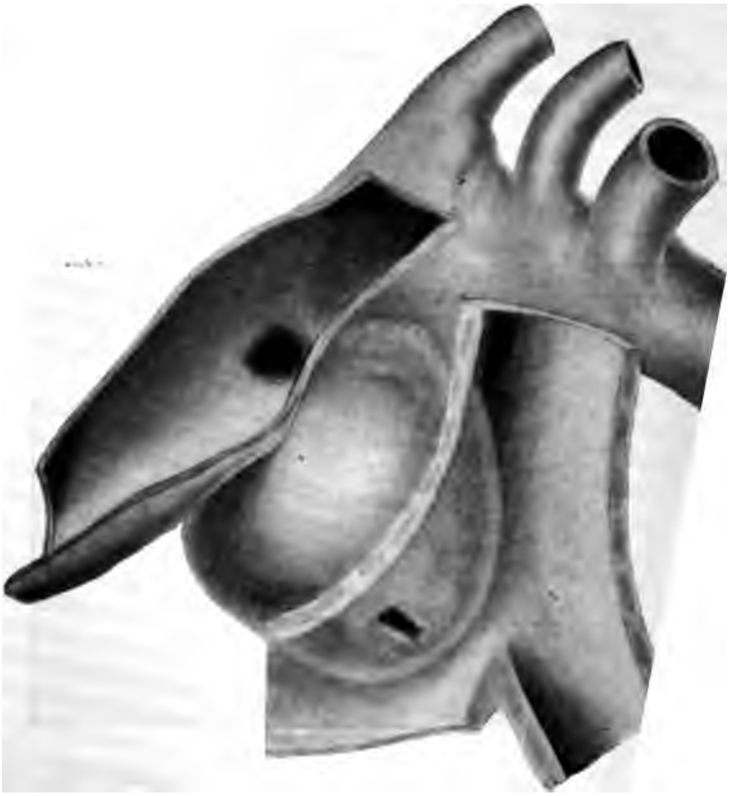


Fig. 372.—Aneurysm rupturing into bronchus. To the left and aorta with the aneurysmal aperture exposed. To the right and below bifurcating. In the right main bronchus (left in figure) is an apertu [illegible] edge. This directed the blood upwards.

be so injured as to promote thrombosis. **Occlusion of the artery** by preventing the rapid renewal of blood encourages thrombosis. The occlusion may be brought about by **ligaturing** the vessel. Again the artery is sometimes pressed on by the bulging aneurysm itself, and obliterated. Or the aneurysm having burst, the blood collecting outside, by its pressure, obliterates the aneurysm.

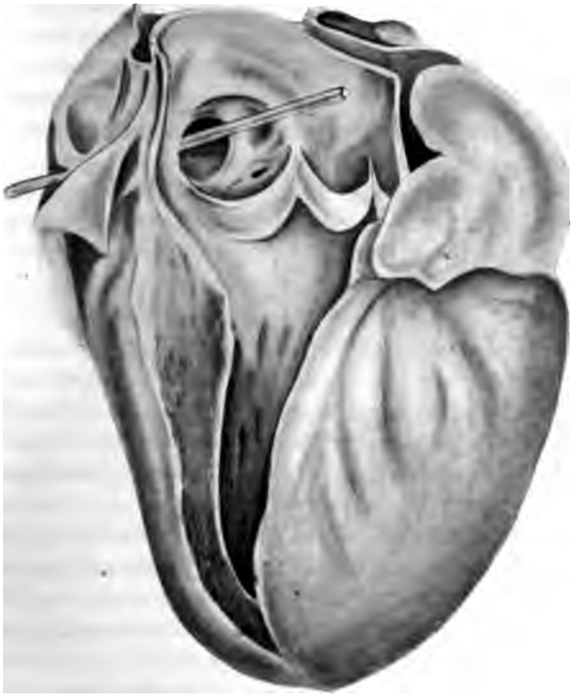


Fig. 373.—Aneurysm of the first part of the arch of the aorta opening into the pulmonary artery. The heart and aorta laid open, showing the origin of the aneurysmal sac immediately above the anterior cusp of the sigmoid valve: the aneurysm tending towards the pulmonary artery which is seen, laid open, to the left of the drawing, a probe being passed from the sac into the pulmonary artery by an opening which is not visible in this figure but is prominently displayed in Fig. 374. The small opening to the right, within the sac, is that of the coronary artery.

But the majority of aneurysms are beyond the reach of surgical interference, and for the most part they continue enlarging till they lead to a **fatal issue**. This may be from the effects of **Pressure on parts around**, or upon the heart, so that death may result from hyperæmia and œdema of the lungs, from general venous engorgement and œdema, from marasmus, and so on.

The aneurysm sometimes ends by **Rupture**, which occurs in various directions according to the circumstances of the aneurysm. It may here be said that the probability of rupture is by no means in proportion to the size of the aneurysm. A large aneurysm, by the amount of pressure it exercises, will probably, by its irritation, and by causing counter-pressure from displaced organs, produce sufficient support. When rupture occurs it is either into a cavity of the body, as the sac of the pericardium, the pleura, an auricle of the heart, etc.; or into a canal, as the trachea, bronchus (see Fig. 372), or another blood-vessel, such as the pulmonary artery (see Figs. 373, 374), or into the substance of an organ, as the lung or brain; o among the muscles or connective tissue of a part. The mode i which the rupture comes about varies somewhat. The aneurys may rupture into a cavity or on the surface of the body for wan of support to its wall, a tear occurring by and by in the sac. O the aneurysm may undermine a mucous membrane or the skin, an produce a necrosis, rupture occurring on the separation of the sloug (as in Fig. 372). Or the aneurysm may induce inflammation of th

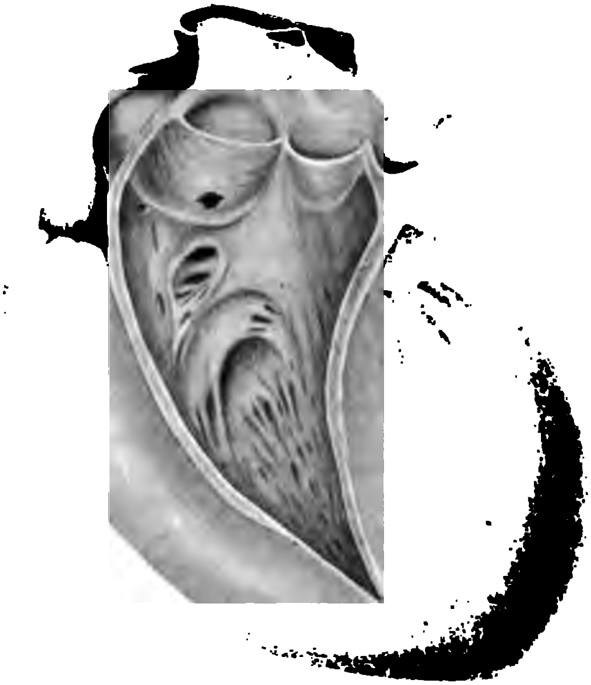


Fig. 374. The aneurysm as seen from the pulmonary artery, with a somewhat ragged opening into the right ventricle (just below the valve), through which the probe is seen to be passed in Fig. 373. The posterior cusp of the valve of the pulmonary artery is seen stretched over the sac. The cut edge of the aorta is seen behind.

mucous membrane, and the softened tissue may give way. Again, in the case of an aneurysm meeting an osseous structure a gap occurs in the wall of its proper sac, as mentioned above, and the edge of the sac may become detached from the bone, and so occasion a rupture. The rupture is not usually at the very first fatal; there is, to begin with, a slight leakage of blood through irregular apertures which get occasionally closed with blood-clot. But from some accidental increase of blood-pressure or other cause the aperture is enlarged, and a fatal hæmorrhage is the result. Or death comes from exhaustion due to the prolonged drain and the interference with function that the aneurysm otherwise produces.

Aneurysms of the **Ascending aorta** are most liable to burst into the pericardium, but they also rupture into pleura, lung, œsophagus, vena cava superior, pulmonary artery, auricle, ventricle, or externally. Those of the **Arch of the aorta** rupture into the trachea or bronchi most frequently, but also into the pericardium and on other neighbouring surfaces. The aneurysms of the **Thoracic aorta** rupture chiefly into the pleuræ, but also into the œsophagus, bronchi, and lungs. Those of the **Abdominal aorta** mostly rupture behind the peritoneum, and enormous quantities of blood may accumulate beneath that membrane, bulging it and the abdominal contents forwards. There may be a subsequent tear of the peritoneum, and blood is, in that case, present in the abdominal cavity. Abdominal aneurysms also rupture into the left pleura, inferior vena cava, lungs, colon, pelvis of kidney, and posterior mediastinum.

8. **Special forms of aneurysms.**—There are certain lesions to which the name aneurysm is commonly given, but which do not accord with the description given above.

(*a*) **Cirsoid aneurysm** and the **Aneurysm by anastomosis** are somewhat allied forms. The **Cirsoid aneurysm** is sometimes called **varix arterialis**, and the name is suggestive of the condition presented. A portion of artery with its branches becomes elongated and widened, and the vessels become convoluted like varicose veins. Sometimes the dilatation extends to the corresponding capillaries and veins. This form of aneurysm occurs most frequently in the arteries of the scalp and face, especially the temporal and occipital, and the enlarged and tortuous vessels are to be felt under the skin. The **Aneurysm by anastomosis** is almost an arterial vascular tumour. There is enlargement and lengthening of a large number of small arteries, with probably new-formation of arteries, and the mass of vessels can be felt like pulsating worms under the skin. The enlargement may extend to the capillaries. The affection forms a distinct growth of a bluish-red colour, with a somewhat granular surface. Its most frequent seat is the scalp.

(*b*) **Traumatic aneurysm.**—This arises in consequence of an injury to a vessel. An injury has been sustained, and after a longer or shorter period an aneurysm appears. The mode in which such aneurysms arise varies. In some cases an artery is wounded, and th blood makes a cavity for itself, constituting a **Spurious aneurysm** The cavity remains in communication with the artery, and forms kind of aneurysmal sac. This is not a common result of wounds c arteries, as these usually close, but it does occur, and most readil when the wound has been an oblique or longitudinal one. It ma result from a penetrating wound of such a form as to prevent th escape of the blood from the surface, or it may result from a broke bone tearing the coats.

But there are some cases of traumatic aneurysm which are mo slow of formation and in which it is not probable that any distin tear through the whole coats has occurred. In the fully develope aneurysm it is impossible to trace the exact mode of origin, but is probable that in many cases a fractured bone projected against vessel injures or even ruptures the middle coat, and possibly t internal as well. We know that in applying a ligature those tw coats give way, and we can conceive a violent force applied to t wall producing the same result. A simple blow may act in a simil way, but it will do so the more readily if the middle coat be alrea brittle from calcareous infiltration. Many of the aneurysms of t femoral and popliteal arteries are referred to blows and injuri but these are not all to be regarded as pure traumatic aneurys as the arterial coats are frequently so altered by atheroma a calcareous infiltration that the injury seems to be merely the det mining cause.

Traumatic aneurysms, as appears from what has been said as their origin, have usually less defined sacs than spontaneous on This is especially the case in those which arise directly from wounc

(*c*) **Dissecting aneurysm.**—In this form the blood is not in a distin sac, but is within the coats of the artery itself, a false passage bein formed amongst the layers of the middle coat. The blood finds it way into this situation by rupture of the intima and internal layers o the media (see Fig. 375). It sometimes arises from an injury, and i thus a traumatic aneurysm, but it more frequently occurs spontaneously and it is frequently multiple. The author has met with a case i which there were four separate dissecting aneurysms on the aort and its branches. It may be inferred from this fact that th condition is often due to an abnormal brittleness of the intern coat, apparently not from atheroma or any other definite diseas of the coat, but an inherited or acquired brittleness. The intern coat is torn through, and the blood passes among the fibres of t middle coat. It is not that the middle coat is dissected up from the internal coat, but the layers of the middle coat itself are separated, and the blood lies between an external and an internal

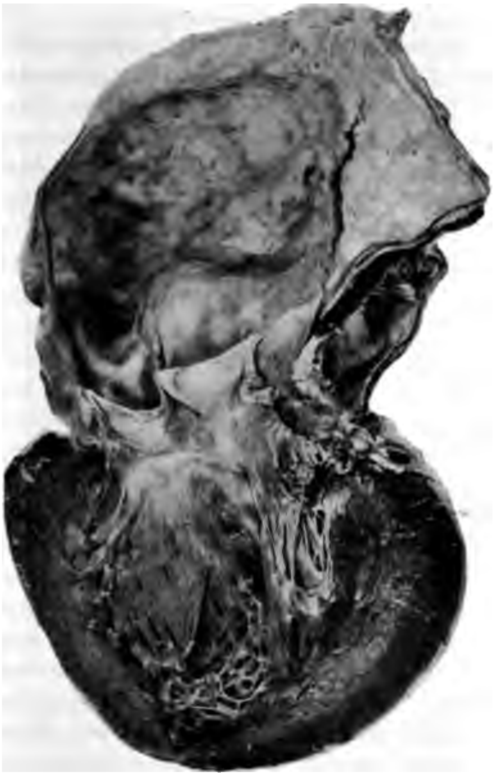


Fig. 375.—Rupture of aorta with commencing dissecting aneurysm. An elongated rupture is shown in the atheromatous aorta. An accumulation of blood is seen in the layers of the middle coat at the lower cut edge of the vessel.

layer of the middle coat, as in Figs. 376, 377, 378. The splitting up of the middle coat may be carried a considerable distance, and after passing along in the wall of the vessel the blood may make another tear in the internal coat and pass back into the vessel. The aneurysm may thus come to have two apertures, and a condition may occur as if the vessel were formed of a double tube, divided longitudinally by a septum composed of the internal and a part of the middle coat (see Fig. 377). The circulation may even be carried on to a great extent through the aneurysm, the blood passing in at the original aperture and out at the secondary one. In the case already referred to and partly shown in Fig. 377, one

of the aneurysms began in the thoracic aorta, and was co
down into the iliac arteries. There were two apertures,
the thoracic, and the other far down in the abdominal aor

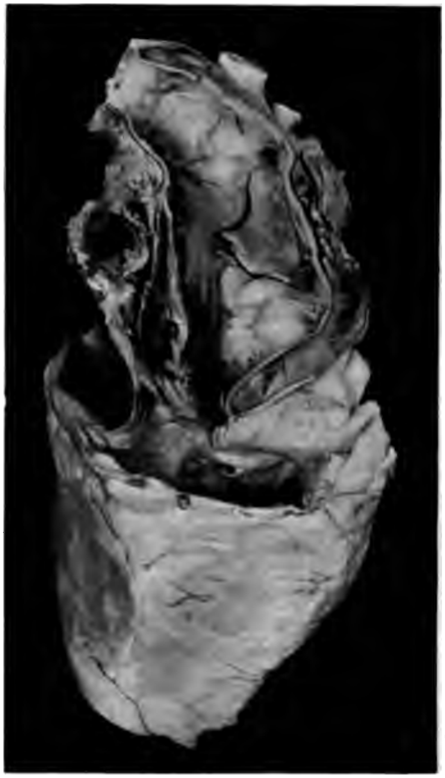


Fig. 376. -Dissecting aneurysm of aorta. Posterior aspect of heart. A large
ture, angular in form is shown. Somewhat pale coagula are seen between the la
of the media.

between these the aneurysm had evidently carried on the cir
to a greater extent than the natural channel. The approxima
such an aneurysm in character to the regular channel is still
increased by the fact that the aneurysm by and by acqu
internal lining resembling the internal coat. It is a homo
membrane of about the thickness of the internal coat, so th
section it may be difficult, even under the microscope, to say
a particular place is the wall of the vessel or the wall of the an
(see Fig. 378). In that case the proper calibre of the arte
become considerably narrowed.

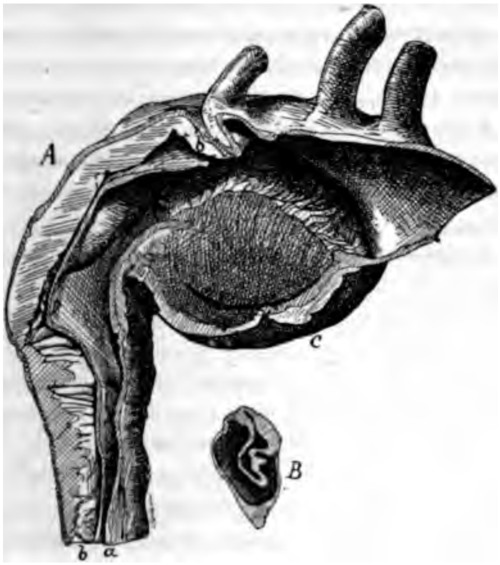


Fig. 377.—Dissecting aneurysm of aorta. In A, a longitudinal section shows the two tubes, the natural calibre *a*, and the aneurysmal one *b b*, the latter largely occupied by clot. The hollow of the arch is largely occupied by a clot at *c*, there being here a partial rupture of the coats. B is a transverse section. The proper calibre is greatly reduced, and the separation has extended round about three-fourths of the circumference. (From a preparation in the Western Infirmary Museum.)

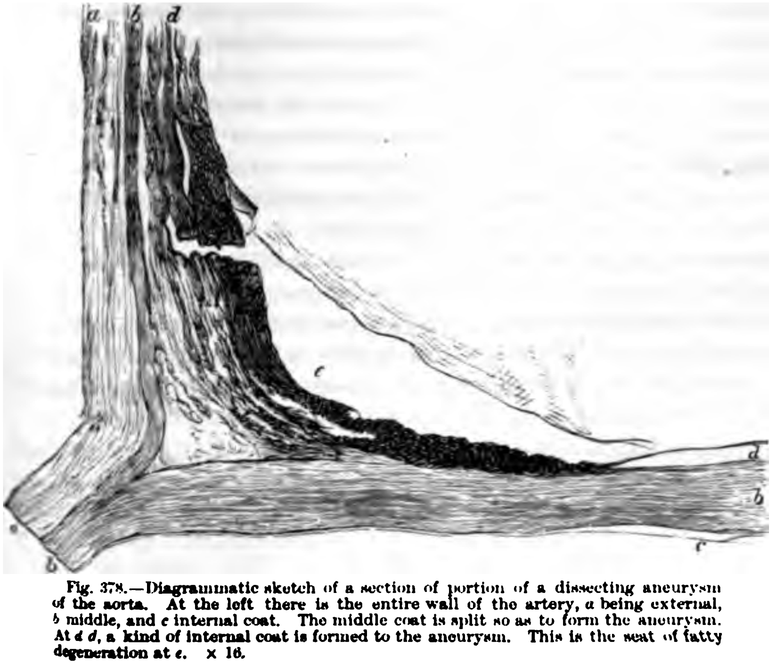


Fig. 378.—Diagrammatic sketch of a section of portion of a dissecting aneurysm of the aorta. At the left there is the entire wall of the artery, *a* being external, *b* middle, and *c* internal coat. The middle coat is split so as to form the aneurysm. At *d d*, a kind of internal coat is formed to the aneurysm. This is the seat of fatty degeneration at *e*. × 16.

2 O

Dissecting aneurysms being confined to the wall of the vessel appear externally as thickenings or dilatations of the wall, and they may produce bulging or bagging of the vessels to a remarkable degree. Occasionally a dissecting aneurysm tears through the remaining layers of the middle coat and the external coat, and so a spurious aneurysm is attached to a dissecting one.

(*d*) **Varicose aneurysm** is a term applied to the case in which an artery and a vein acquire a permanent abnormal communication. It may arise spontaneousl or traumatically. This form used to be not uncommon at the bend of the elbow when, in performing venesection, the lancet wounded artery and vein together. I occurs spontaneously when an aneurysm ruptures into a vein. In some cases ther is an actual aneurysmal sac between artery and vein, and to this form the nam **Varicose aneurysm** is more properly applied. But the communication may b direct, and while the artery is little dilated the vein is enlarged, tortuous, an pulsating. To this form the name **Aneurysmal varix** is applied. The interferen with the venous current produced by the violent injection of the arterial bloo especially if it be suddenly produced, may lead to serious venous engorgement a œdema, which may even have a fatal issue. Spontaneous communications of th kind have been observed in cases of bursting of aneurysms between the aorta a venæ cavæ, between the crural and popliteal arteries and the corresponding vein between the splenic artery and azygos vein, and between the internal carotid a the sinus cavernosus.

9. **Syphilitic and Tubercular affections of arteries.**—These aris usually by extension of the infective process to the arteries, and ar generally part of a larger and more pronounced lesion.

Syphilitic affections of the arteries occur in the neighbourhood of gummata, more especially of the brain and its membranes. There is an extension of the specific inflammation to the walls of the artery, so that the coats are infiltrated with leucocytes. The internal coat may undergo great thickening, so that the condition resembles that in obliterating endarteritis (see Figs. 58 and 59, pp. 183, 184). A more unusual syphilitic lesion is a localized inflammation of an artery without the presence of a gumma in the neighbourhood. The artery is thickened and has a cartilaginous consistence, while the calibre i greatly reduced. This condition, which occurs chiefly in the arterie of the brain, resembles atheroma of these vessels, but is more limite in its distribution.

There is considerable doubt as to the existence of a special gummatous en arteritis as described by Heubner, and the influence of syphilis in affecting th arteries has been exaggerated. A lesion of an artery is not to be regarded a syphilitic unless it be either directly connected with a syphilitic lesion, or in th absence of a general atheroma, is associated with syphilitic disease elsewhere.

Tuberculosis of organs not infrequently extends to their arterie The wall of the artery is infiltrated with leucocytes and its tissu opened out and softened. There may result aneurysm or even hæmorrhage, although the advancing tuberculosis usually closes the artery by thrombosis. (See under Tuberculosis of the lungs.)

Literature.—Crisp, Treatise on structure, diseases, and injuries of blood-vessels, 1847; Köster, Pathogenese d. Endarteritis, 1874; Friedländer (Arteritis obliterans) Virch. Arch., lxiii., 355; Stilling, Heilung durchschlungener Gefässe, 1834; Thoma (Arteries in stumps), Virch. Arch., xciii., also (Atheroma) Virch. Arch., civ., cv., cvi.; Weber, Pitha and Billroth's Handb., Bd. i., Abth. 1; Cornil et Ranvier, 2nd ed., 1881, i., 598; Paget, Lect. on surg. Path.; Paul (Ossification) Path. Trans., 1886; Coats, (do.) Glasg. Med. Jour., Ap., 1887; Cohn, (do.) Virch. Arch., cvi., 378. *Aneurysm*—Bizot, Mém. de la Soc. méd. d'observation, vol. i., 1836; Hodgson, Lect. on dis. of art. and veins, 1815; Crisp, loc. cit.; Broca, Des aneurysmes, 1856; Köster, Berl. klin. Wochenschr., 1879; Coats and Auld, Brit. Med. Jour., 1893, ii., p. 456, and Journ. of Path., 1895; Gairdner, Allbutt's System of medicine, vol. vi., 1899; Trans. Path. and Clin. Soc. Glasgow, vi. and vii., 1897, 1898. *Tuberculosis*—Stroebe, Centralb. für Bakter, viii., 1897; Blumer, Amer. Jour. Med. Sciences, cxvii., 1899. *Syphilis*—Allbutt, St. Geo. Hosp. Rep., iii., iv., Heubner, Die luetische Erkrankung der Hirnarterien, 1874; Baumgarten, Virch. Arch., lxxiii.; Huber, ibid., lxxix.; Abramow, Ziegler's Beiträge, xxvi., 1899.

II.—DISEASES OF THE VEINS.

1. **Thrombosis.**—This is of very frequent occurrence in veins. The full description of this process in a previous section applies especially to the veins. As the blood in the veins is normally at a low pressure and flows slowly, it is readily brought to a standstill, especially in the pouches of the valves. Hence, any cause which produces prolonged passive hyperæmia or weakness of the circulation is apt to induce thrombosis. Thrombosis is also a result of inflammation of veins, such inflammation being mostly septic.

Thrombosis induces an **Inflammation of the wall** of the vein, whether the thrombus be specially irritating or not. In the case of a simple thrombus its presence induces a chronic inflammation which extends through the wall of the vein to its adventitia and surrounding connective tissue. There are thus **Adhesions** formed between the vein and its sheath, and these may extend to the sheath of the neighbouring artery, causing considerable matting around. A vein containing an old thrombus is therefore, as a rule, somewhat difficult to dissect clean from the surrounding tissue. Thrombi in veins not infrequently become organized, and there may be a partial restoration of the calibre in the manner described at pp. 83, 84. (See also Fig. 379.)

2. **Inflammation of veins. Phlebitis.**—The simplest form of phlebitis is that just referred to in which a thrombus causes a chronic inflammation of the wall of the vein. We may also have an inflam-

mation of the wall from inflammations in the neighbourhood w may or may not induce thrombosis secondarily.

Septic phlebitis or Thrombo-phlebitis. Pyæmia.—These condi were formerly of frequent occurrence and much discussed in me literature. Thrombo-phlebitis usually results from the entran septic matter into a vein, the mouth of which lies open in a wo but it may occur from the extension of a septic inflammation alon sheath of the vein and thence inwards.

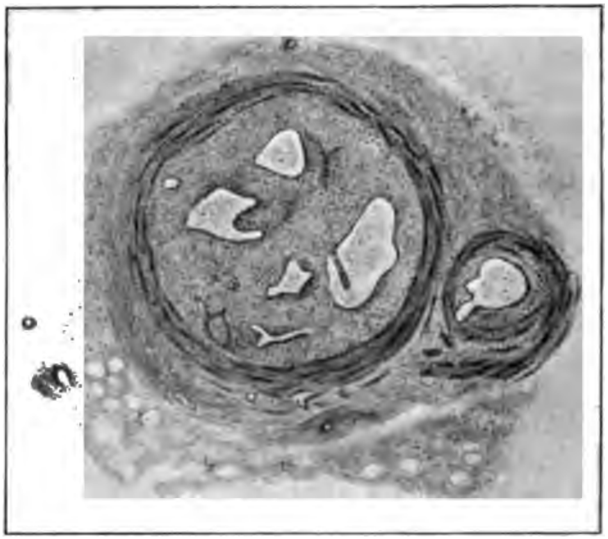


Fig. 379. Two veins with organized thrombi in them. The thrombi contain channels by which the circulation is restored. × 8.

Septic matter introduced into the calibre of a vein induces tion of the blood which, from the circumstances of the case, i already stagnant. The thrombus thus formed is not a simpl contains septic microbes, namely, pyogenic micrococci. The a strong irritant inside the vein, and this induces an acu mation of its wall. There is an exudation of leucocyt serum, which accumulates in the interstices of the wall and the external and middle coats. The exudation rapidl purulent, and the coats are still further opened out. V within there may be little collections of pus visible beneath coat like pustules. This passes into the calibre of the the thrombus softens the vein will often come to be fill The softening of the thrombus is partly the result of the p pus, and partly arises from septic decomposition. The contents of the vein, by the softening of the thrombus, are allowed to pass into the circulation, although fresh thrombosis may from time to time shut them off. The phenomena of **Pyæmia** result from the carriage of septic matter by the blood and the consequent infection of distant parts. From the veins, the most direct connection is with the lungs, where septic embolism is set up. But there is frequently an extension beyond the lungs by the systemic arteries to heart, kidneys, etc.

Literature.—HUNTER, Works, edited by Palmer, 1837, iii., 581; HODGSON, Dis. of art. and veins, 1815; ROKITANSKY, Handb. der path. Anat., ii., 1844; VIRCHOW, Ges. Abhandl., 1857; EBELING, Ueber Phlebitis, 1880; PANTON, Uterine phlebitis, Glasg., 1840; LEE, Origin of inflam. of veins, 1850.

3. **Varix or Phlebectasis.**—Varix is dilatation of veins just as aneurysm is dilatation of arteries.

Causation.—We saw that some weakening of the wall is always necessary to the occurrence of aneurysm, but no such condition is required in the production of varicose veins, although a certain looseness of texture, in some cases hereditary, undoubtedly predisposes. The walls of veins are already thin, and the blood-pressure within them is low. In the case of the veins of the skin we are familiar with the fact that, as a rule, the blood-pressure is not sufficient to overcome the atmospheric pressure to any considerable extent and the veins are flattened or partially collapsed, a slow and weak current passing through them. The circulation must be considerably excited, or the veins must be obstructed in order to make them stand out as cylinders under the skin. Such being the case it may be conceived that the thin-walled veins, accustomed to a slight blood-pressure, will readily dilate when exposed to an increased blood-pressure. Varix is always due to some cause which is calculated to increase the blood-pressure within the veins, such as obstruction of the veins by thrombi, tumours, the gravid uterus, passive hyperæmia from heart disease, and so on.

Character of the changes.—In the early stages of varix, as may frequently be seen in the legs, there is simply an exaggeration of this natural dilatation above the valves. When we stand erect the column of blood in the veins of the legs is, as it were, supported at each valve, and the downward pressure tells on the valve and the portion of the vessel forming the valvular sinus. Hence this part of the vessel is the first to dilate when the blood-pressure is increased, and the first sign of varix is an exaggeration of the knotted state of the veins. At the outset each valve forms a kind of fixed point, the dilatation occurring at its level, and diminishing as the valve next above is approached. As the dilatation increases and extend the valve, the vein increases in length as well as in calibre, an to be accommodated it begins to form **Curves** or **Convolutio** begin those sinuosities which are so characteristic of varicose which tend to increase as time goes on (see Fig. 380). The

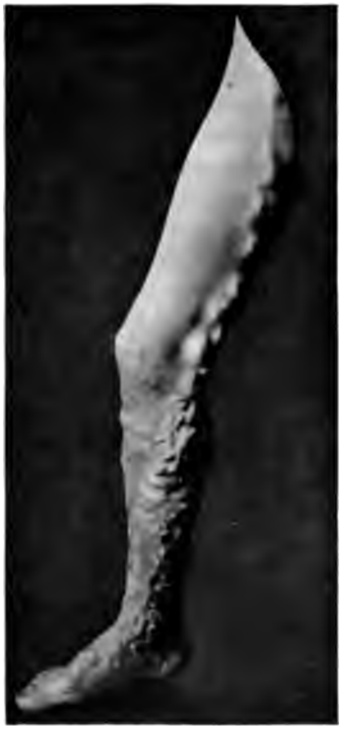


Fig. 380.—Varicose veins of leg.

of the vein has a tendency **the valves incompetent,** occurs all the sooner as of the valves is, as we hav part where the pressur exercised. When the valv incompetent the pressure 1 more on the walls of the the column of blood is no at longer intervals. Th acts most on the depend of the sinuosities, and the projection of these. way we may have wide si their convexity downwar some cases even dive pouches projecting from (see Fig. 381). In these ex dilatations the blood greatly, and it is not unco **Thrombosis** to occur. T obstructed more or less c by the thrombus, which m ize. On the other hand, often dries in and become nated with lime salts. In this way varicose veins frequentl the seat of vein-stones or **Phleboliths.** These are not i in the prostatic and uterine veins (see Fig. 382).

Chronic inflammation is common in the tissues around vari wherever they may be, and so in the skin we often have very eczema with a brown coloration of the skin, which may be r hæmorrhage by diapedesis from the hyperæmic vessels. T indurated and thickened, and this along with the swelling of may be so great as to produce an appearance like that in ele **Ulceration** is often induced, and the ulcer is sometimes deep gish, and may persist for years. There is sometimes great t of the walls of the swollen veins at the base of varicose ulcers.

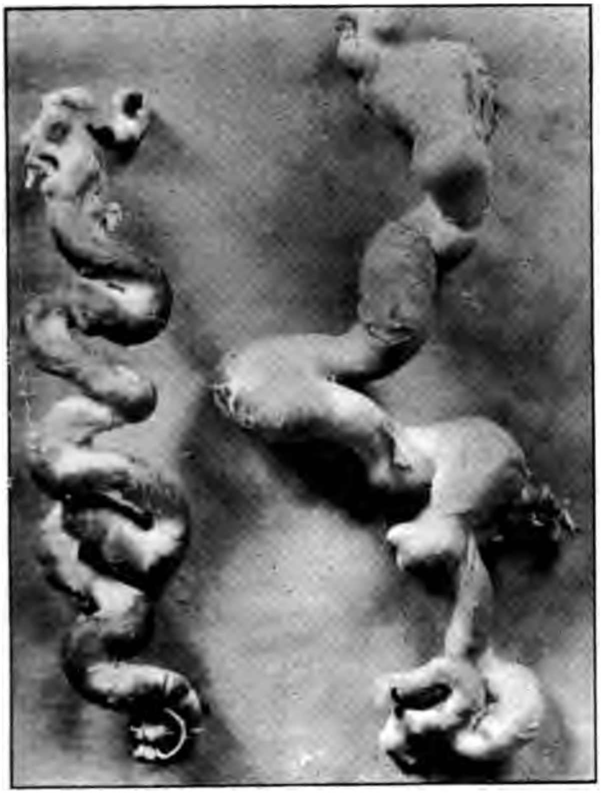


Fig. 381.—Varicose veins of leg which were removed by operation.

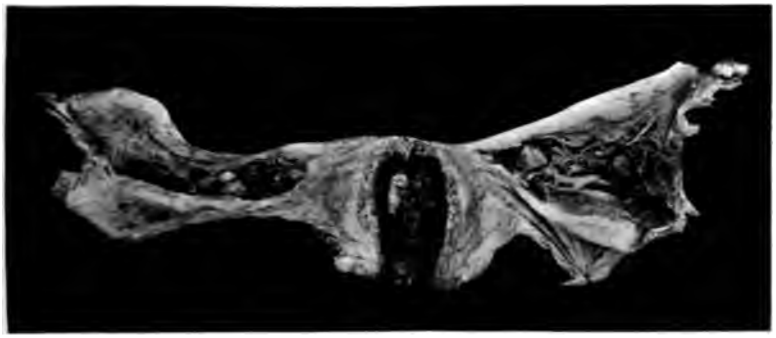


Fig. 382.—Thrombosis of veins in broad ligament. Several of the thrombi have been converted into phleboliths. The latter have a whitish-yellow colour.

apparently, a compensatory thickening to resist the excessive pre (see Fig. 383).

A varicose vein **may burst.** It may be opened by the ulcer process, or it may come to the surface and by its increasing dilat at last rupture. In the case of the leg the results are sometime ceedingly serious. As one effect of the dilatation is to render the v incompetent, the veins of the entire leg may come to be virtually d of valves. But the veins inside the abdomen are normally devo valves, and so it may happen that from the lower part of the leg the heart there may be a single column of blood without an arre valve. If now a vein rupture in the leg, the whole system up t heart may be, as it were, tapped, and if the person is in the posture a fatal hæmorrhage may result. The hæmorrhage will ce the person lies down, but cases have been known in which an imm amount of blood has been shed into the boots without warnin

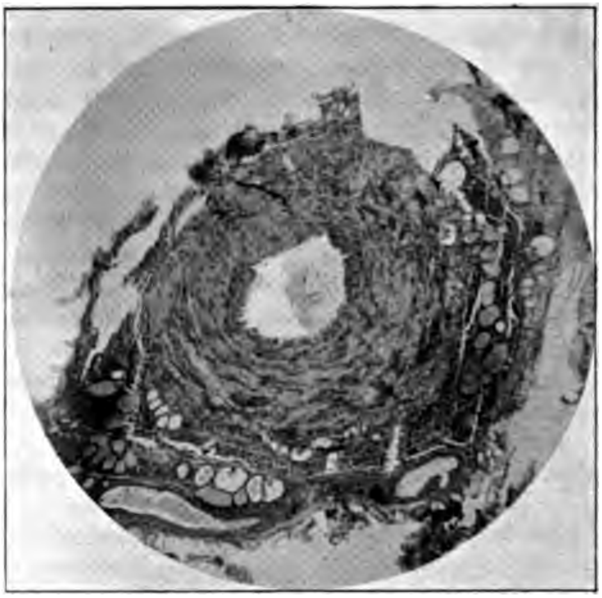


Fig. 383.—Vein with hypertrophy of its wall from the base of a varicose ulcer. × 18

Hæmorrhoids are varicose veins of the lower rectum. At the part of the rectum a network of small veins surrounds the bowel, immediately under the mucous membrane. These veins commun with the inferior mesenteric vein, which is a tributary of the porta and with the internal iliac, which is a tributary of the vena cava.

obstruction in the portal circulation, or abnormal pressure within the abdomen is apt to induce dilatation of this hæmorrhoidal plexus. The dilated veins push the mucous membrane before them, and protrude as bluish nodules either immediately within or without the anus. They may assume considerable dimensions. The knots are composed originally of a congeries of small convoluted veins (Fig. 384, *B*), which may communicate so as to form a kind of cavernous tissue, but sometimes there are large ones (Fig. 384, *A*). Through time the mucous membrane undergoes alterations. The piles at each movement of the bowels are exposed to mechanical irritation, and so the mucous membrane is almost constantly in a state of catarrh. Then at intervals, when the blood-pressure is unusually great by reason of an attack of inflammation or otherwise, the veins rupture, and so there is bleeding,

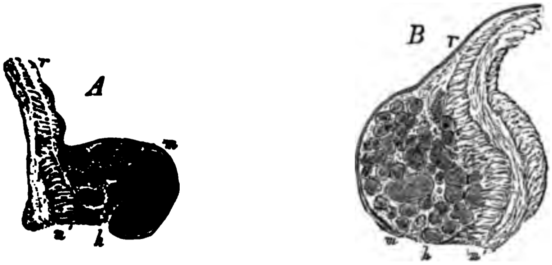


Fig. 384.—Hæmorrhoids of rectum, in section, natural size. *r* is internal surface of rectum, and *m* the mucous membrane continued over the hæmorrhoid. At *m'* is represented the muscular coat, the dilated veins being in the submucous tissue. At *A*, the veins are few but much dilated, one especially so, just beneath the mucous membrane. At *B*, the dilated veins are more numerous, but smaller. Both occurred in the same case. (VIRCHOW.)

oth in the substance of the mucous membrane and on to the surface. he hæmorrhoids thus become greatly altered. They become condensed om inflammatory new-formation of connective tissue. They sometimes ecome the seat of collections of blood, which may form blood cysts. hleboliths may also form in the veins. More severe inflammations ometimes occur, resulting in abscesses, fissures, fistulas, or ulcers.

Varicocele is a dilatation of the veins of the spermatic cord and the xternal scrotal veins. It affects in a greatly preponderating proportion the left side, the explanation of this being apparently that the left spermatic vein has a circuitous course, and enters the renal vein at a right angle, while the right opens into the lower vena cava. The varicosity generally begins at the external inguinal ring, and extends downwards as far as the testicle. There is not infrequently atrophy of the testicle, and sometimes hydrocele or hæmatocele.

Varix may occur in other veins, such as those of the **Neck of the**

bladder and **Prostate**. It is also met with in the female in the **Vesical plexus** and veins of the **Vagina**, and this may be combined with varix of the **Broad ligament** (see Fig. 382). Varicosity also occurs in the veins of the **Dura mater**.

4. **New-formations in veins.**—**Syphilis** rarely attacks veins, but a gummatous inflammation has been observed in the portal vein and in the umbilical vein in new-born children. **Leprosy** may attack the large veins of the extremity.

Tuberculosis affects veins in organs which are the seat of this process, and produces results similar to those in arteries. As the walls of veins are thin the process more readily penetrates to their calibre, and the tubercle bacillus may thus find entrance to the blood. Tuberculosis of veins is the most frequent cause of general tuberculosis, as already described.

Primary tumours of veins are excessively rare. A few cases of small **Myomata** have been described, and a larger tumour which was regarded as a myo-sarcoma (Perl). Tumours not infrequently penetrate into veins, on account of the thinness of their walls, but do not produce tumours in them.

Literature.—Brodie, Lectures on Path. and Surgery, 1846; Nunn, Varicose veins and ulcers, 1852; Chapman, On varicose veins, 1856; Gay, Varicose dis. of lowe extrem., 1868; A. Cooper, On spermatocele, Guy's Hosp. Rep., vol. iii.; Virchow, Virch. Arch., iii.; Cohnheim, ibid., xxxvii.; Köster (Phlebectasis in intestine), Ber klin. Wochenschr., 1879; Lesser, Virch. Arch., ci.; Epstein, ibid., cviii.; Per ibid., liii.

SECTION II.—CONTINUED.

C.—DISEASES OF THE LYMPHATIC SYSTEM AND SPLEEN.

I. **The Lymphatic Vessels.**—Inflammations. Tuberculosis. Dilatation from obstruction of the thoracic duct and other stems. Tumours, including secondary cancer. II. **The Lymphatic Glands.**—1. Their structure and general pathology. 2. Degenerations. 3. Pigmentation leading to induration. 4. Acute lymphadenitis, Bubo. 5. Chronic lymphadenitis. 6. Tuberculosis, primary and secondary. 7. Syphilis. 8. Tumours. III. **The Spleen.**—Its structure. Malformations and malpositions. Active congestion and inflammation; the acute splenic tumour. Chronic inflammation; the chronic splenic tumour. Passive hyperæmia. The embolic infarction. Rupture. Amyloid disease; the sago spleen; the lardaceous or waxy spleen. Tuberculosis, syphilis, and tumours.

I.—THE LYMPHATIC VESSELS.

WE have already had occasion to observe that the lymphatic system is intimately related to the blood-vascular system, and may be regarded as a part of it. We have also seen that this system has close relations to the connective tissue, the spaces in the latter being lymph spaces lined with endothelium and having direct connections with the lymphatic vessels. Wherever there is increased exudation from the blood-vessels the serous spaces and lymphatic vessels are distended, and the current through them increased. We have seen this to be the case in inflammations and œdemas.

Inflammation of the lymphatics. Lymphangeitis.—The lymphatics are liable to inflammations of a more independent kind warranting the name lymphangeitis. In order that such inflammation may occur there must be in the vessels some irritant, and the irritant is similar to that which we find in the veins in suppurative phlebitis, namely, a septic poison. Just as in the case of veins there is a thrombosis with suppurative inflammation (see thrombo-phlebitis), so here there is a coagulum formed which breaks down as suppuration goes on. In connection with wounds which have been exposed to decomposing juices, such as dissecting wounds, we sometimes find the course of the lymphatic vessels marked by red streaks in the skin. T represent inflammation of the lymphatics and surrounding conne tissue. The inflammation not infrequently goes on to suppur so that abscesses form at intervals in the course of the ve Here also, as in thrombo-phlebitis, there is a transportation o septic matter, but it is caught by the lymphatic glands, whic liable to suppuration in consequence.

Erysipelas and other phlegmonous inflammations of the ski inflammations primarily of the lymphatics and of the serous s which form the radicles of the lymphatics. Microbes are pres the lymphatics of the skin in such cases (see under Diseases o Skin), and they may be so numerous as to render [illegible] lym vessels as well as the serous spaces peculiarly prominent, whe sections have been stained by aniline dyes. The phlegmono flammation of the parotid, which occasionally occurs in cases of wounds, is probably of a similar nature. Epidemic parotitis (m may perhaps be placed in the same category.

We have already seen that **Elephantiasis frequently begi** recurrent attacks resembling erysipelas, in which the lymphatic v are obviously affected. There are often red streaks passing u limb, and the lymphatic glands may be enlarged. The irritatio is slighter and more chronic. The inflammation results in thickening of the connective tissue, but there is often along w dilatation of the lymphatic vessels, so that, when the part is cu an abundant lymphatic fluid exudes which sometimes contains fa

Tuberculosis of the lymphatics.—This is very frequent in conn with tuberculosis of various parts. Thus in tuberculosis of the int there are often visible beneath the peritoneum prominent white which are tuberculous lymphatics. In the lungs also tuber frequently extends by the lymphatics. The **Thoracic duct** is times the seat of a regular tuberculous eruption in general tuberc (Orth.)

Lymphangiectasis.—The lymphatic vessels are occasionally th of **dilatation. Obstruction of a lymphatic stem** may produce a va dilatation of the vessels and even their rupture. The most st example of this is afforded by **Obstruction of the thoracic** This is not an infrequent accident, arising from various causes, s pressure of tumours, aneurysms, etc., in its neighbourhood, but particularly from thrombosis of the jugular and innominate (see under Œdema and Dropsy). Experiments on animals sho ligature of the duct leads to dilatation and sometimes to rupt its dilated origin in the abdomen, which forms the Cysticern

(Cooper). In man there may be a similar rupture, either in the abdomen or pleura, leading to accumulation of fluid in these cavities. As the fluid in the thoracic duct contains fat, the exudation in the peritoneum or pleura will be chylous (see Chylous Ascites and Hydrothorax). Rupture is, however, only an occasional result of obstruction of the duct, as the anastomosing connections may compensate, so that there may even be comparatively little dilatation. We have already seen that when the lymphatics are obstructed by the embryoes of the filaria sanguinis, **Lymph-scrotum, Chyluria,** etc., may result. In the enlargement of the tongue called **Macroglossia**, which is frequently congenital, there is commonly a great dilatation of the lymphatics, which may form considerable cysts. Sometimes the whole lesion has the aspects of a tumour-formation.

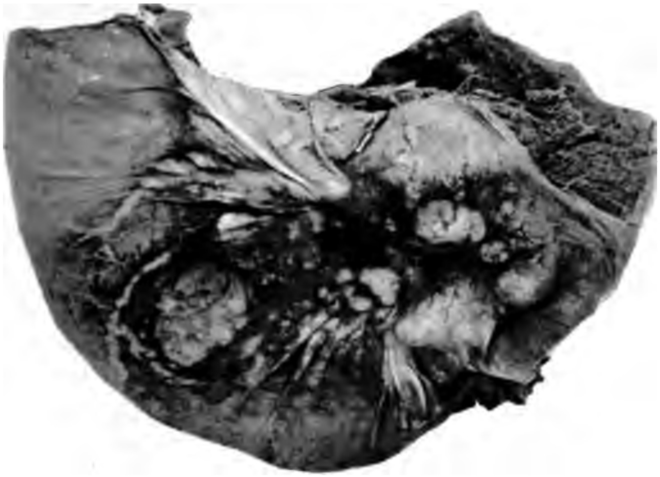


Fig. 384.—Secondary cancer of a mesenteric gland. The involvement of the lymphatics is well shown.

Tumours of the lymphatics.—There is sometimes a localized dilatation of many lymphatics so as to form a distinct **Vascular tumour.** These tumours are usually cavernous in structure, and are classed as **Cavernous lymphangiomas.** Sometimes they develop actual cysts, which are filled with serous fluid, and are designated **Hygromas.**

We often find lymphatic vessels dilated in the neighbourhood of a **Cancer,** the material in the vessels being derived from the tumour. This occurs mostly in the case of cancers which are undergoing softening. It is most frequently seen in connection with mammary cancers, where the lymphatics may have the form of firm cylinders as large as quills, filled with white material (Fig. 385). The same thing is seen in the case of secondary cancer of the lung, where there are nodules immediately under the pleura. The subpleural lymphatics around the nodule are found, as it were, injected with white material, and this also occurs in the capsule of the liver when cancerous nodules are near the surface. These naked-eye appearances indicate how prone cancerous material is to pass into the lymphatics, and under the microscope at the margins of a growing cancer the lymph-spaces may sometimes be found filled with epithelial masses. (See under Cancer.)

Literature.—VELPEAU, Arch. gén. de méd., 1835, viii.; BRESCHET, Le système lymphatique, 1836; CARTER (Lymphangiectasis and Elephantiasis), Trans. of Med. Soc. of Bombay, 1861; ISRAEL, Ueb. Lymphangioma, 1885; BRADLEY, Injuries and dis. of lymphatic system, 3rd ed., 1875; COOPER, Med. records and researches, 1798; BÖGEHOLD (Injuries of thor. duct), Arch. f. klin. Chirurg., xxix., 443; COATS, Museum Catal. of Western Infirmary (Obstr. of thor. duct from thrombosis of jug. vein).

II.—THE LYMPHATIC GLANDS.

1. **Structure and relations.**—All lymphatic vessels connect themselves directly with lymphatic glands, so that no lymph passes into the circulation without first traversing a lymphatic gland. Dissolved substances introduced into the lymphatic spaces of the skin and subcutaneous tissue are rapidly carried up the lymphatics and through the glands into the general circulation; this is a matter of every day experience in the subcutaneous injection of medicinal agents. Granular material, however, does not pass through the glands, which form a filter for all solid particles.

The apparatus by which the **Filtration of the lymph** is effected is illustrated in Fig. 386. When the afferent lymphatic vessel coming from the periphery reaches the gland, it first forms a plexus in the capsule. On the other hand the efferent vessel emerges from a plexus of vessels at the hilus, and this plexus is connected with the medullary portion of the gland. In passing from the afferent to the efferent vessel the lymph traverses a series of sinuses, *c*, *c*, in figure. The sinuses are not clear spaces, but contain a reticulum or mesh-work shown in the figure. These sinuses surround the proper glandular tissue, which is in the form of rounded follicles or cords composed of densely packed lymph cells (*a*, *a*, in figure). The lymph first passes from the afferent plexus into the sinuses of the cortex, then into those of the medullary part, where originate the radicles of the efferent vessel. The sinuses being occupied by the fine reticulum will catch solid particles brought to the gland, and such particles will therefore be most readily caught at the cortical portion of the gland.

In the normal gland, according to the researches of Flemming and Baumgarten there is an active new-formation proceeding by means of **Karyomitosis**. This occurs at a number of centres in the cortex, whose cells are less deeply stained than those elsewhere, but in which the nuclear figures of karyomitosis are visible. There is also nuclear division in other parts, but to a less degree. These appearances probably indicate the new-formation of leucocytes.

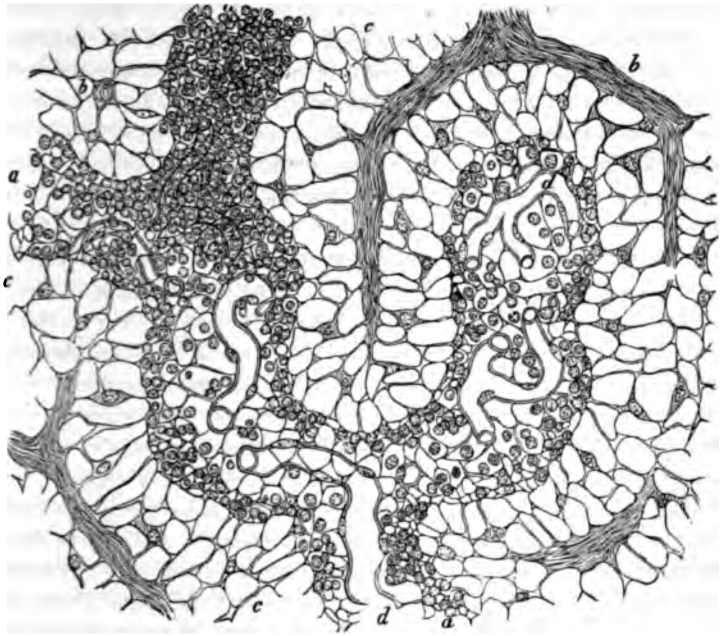


Fig. 386.—Section of normal lymphatic gland ; *a*, *a*, *a*, follicular or lymphoid cords ; *c*, *c*, lymph sinuses ; *b*, *b*, connective tissue trabeculæ ; *d*, *d*, *d*, blood-vessels. ×300. (Recklinghausen.)

In the operation of **Tattooing**, granular pigment, such as Indian ink or vermilion, is introduced into the skin. Part of it remains permanently in the corium, but part is conveyed up the lymphatics and is caught by the glands, where it remains fixed.

So it is in pathological conditions. The lymphatic glands are very frequently associated in morbid processes which are occurring in parts in which the vessels passing to the glands take origin. Dissolved and solid materials are thus conveyed to the glands, and according to the nature of the material will affect the gland or not. In **Septic inflammations**, for example, the microbes are often conveyed to the glands and produce inflammation there. As these are in the form of fine particles they are arrested at the gland, and the inflammation makes a pause there only to proceed further, if the organisms propagate onwards. But even in the case of **Simple inflammations**, although the products are for the most part dissolved, they still are frequently of an irritating nature and cause the glands to inflame. We have seen that solid material from cancers is often conveyed along the lymphati vessels and is caught at the glands.

In all these cases the material may produce no irritation in th lymphatic vessels along which it is being conveyed. If concentrate or very virulent it will do so, but it often does not, and in that ca a wide interval of healthy structure intervenes between the primar disease and the lymphatic gland. Hence it is common to speak the disease being conveyed to the glands by metastasis. Indee most of the lesions to which the glands are liable are secondar to diseases elsewhere, but there are some which may be regarded idiopathic.

2. **Degenerative changes.** These are not of common occurren apart from tuberculosis and syphilis. **Amyloid disease** is the commonest form of degeneration, but it does not usually occur in a hig degree, and it is only occasionally that the glands are enlarged an rendered firmer by the degeneration. For the most part it is detecte only when the glands are examined microscopically with the aid iodine or methyl-violet. The disease appears to attack mainly th reticulum of the gland, and one can sometimes make out the swolle hyaline network, or even detect how the normal reticulum swells o into the degenerated network. In old persons a **Colloid or Hyalin degeneration** is met with. The gland shows a series of alveoli fille with colloid material, or the blood-vessels and trabeculæ of the glan become hyaline, the appearance resembling that in amyloid disease b without the reaction.

3. **Pigmentation of the glands.**—We have seen how pigment art ficially introduced into the lymphatics is arrested at the gland Similarly, carbonaceous pigment is carried from the lungs and deposite in the bronchial glands. Again, in cases of extravasation of blood, in inflammations with considerable hæmorrhage, the red corpuscles a conveyed, sometimes in large numbers, to the glands, which may th be deeply coloured. The dissolved colouring matter in hæmorrhag may also be conveyed and stain the glands.

The pigment is carried, in part at least, by the lymphoid cells, whi are to be found in the lymphatic fluid. Arrived at the gland, t pigment is first caught by the stellate cells which form the reticulum the sinuses of the cortex, and hence in the earlier stages we may ha the sinuses marked out by the pigmentation. If it continues to arri at the gland, it extends into the follicles and finally the whole gla may be deeply and uniformly coloured. When present in such quanti the pigment, although generally non-irritating, produces a **Chro inflammation**. There is increase of the connective tissue forming t trabeculæ, and a corresponding atrophy of the glandular follicles. The affected gland in addition to the pigmentation is enlarged and hard, or **indurated**, and in this state it seems to be to a large extent **stuffed** up by the pigment and rendered impervious. When this is the case the lymph probably passes by anastomosing vessels to other glands, which in their turn become pigmented. In this way we may explain how pigmentation sometimes extends from gland to gland. Thus in anthracosis of the lungs we may have not only the bronchial glands but also those of the mediastinum, and even those of the abdomen and at the porta of the liver pigmented.

What has been said in regard to pigment applies also to other solid materials introduced similarly into the lymphatics. In stone-masons the particles of stone which get into the parenchyma of the lung are in part carried to the glands, where they produce similar changes to those mentioned, but even more readily, as from their mechanically irritating characters they are more apt to produce chronic inflammation.

4. **Acute inflammation of lymphatic glands, Lymphadenitis.**—As already indicated, this condition is nearly always a result of inflammation in the peripheral parts from which the vessels come to the gland. The enlarged and inflamed gland is called a **Bubo**. The most serious of the acute inflammations are connected with infective processes, as in the case of dissecting wounds, erysipelas, phlegmonous inflammations, diphtheria, scarlet fever, splenic fever, and the plague (Bubonic plague).

The inflamed gland is enlarged, its vessels hyperæmic, and its tissue softened. The enlargement is due to a great increase of lymphoid cells which accumulate largely in the sinuses. The stellate cells forming the reticulum of the sinuses also swell, and their nuclei divide. The sources of the added lymphoid cells are several. They arise by division of the existing cells of the gland, as evidenced by the observation of karyomitosis in these cells; but they have their origin in part in the emigration of white corpuscles from the blood-vessels in the gland, and the primary inflammation of the periphery probably sends its contingent. The inflammation may subside and the gland return to its normal condition; the new-formed cells probably pass on into the efferent vessel and are disposed of in the circulation.

Not infrequently suppuration occurs; the tissue of the gland breaks down and an abscess is the result. We have thus a **Suppurating bubo**. The inflammation usually extends to the capsule and surrounding tissue, which become involved in the suppuration. In this way the abscess advances, and the pus is finally discharged at the surface. Usually the abscesses do so discharge, but they may burst into bronchi, into serous cavities, etc. Some of these severe inflammations have a hæmorrhagic and even a necrotic or gangrenous character.

5. **Chronic lymphadenitis.**—This term is used for a simple chronic inflammation in connection with prolonged irritation of the glands. This is most directly produced by the introduction of foreign substances, where the solid particles are conveyed to the glands (see above). It occurs also in connection with prolonged peripheral irritation, as where an eczema of the leg or the scalp produces an enlargement of the corresponding glands. The inflammation here results in increase of the entire elements of the gland, or else in a preponderating increase of the connective-tissue stroma with atrophy of the proper gland-tissue and induration of the gland.

6. **Tuberculosis of the lymphatic glands** (*Scrofula*).—Tuberculosis occurs in the lymphatic glands as elsewhere, as a result of the action of the tubercle bacillus. In some cases there is an obvious propagation of these microbes from an existing local tuberculosis at the periphery but there are many cases where the primary seat appears to be in the glands.

Primary tuberculosis occurs for the most part in glands connected with mucous membranes having absorbent functions. There is usually at the outset catarrh of the mucous membrane, and it may be presumed that here, as elsewhere, the exuded products of inflammation are conveyed to the glands. There is no reason to believe that these catarrh are, in the proper sense, tubercular, but it appears that, along with th inflammatory products, bacilli may be carried from the surface. I susceptible persons these will multiply in the glands and produce tuberculosis. Such primary tuberculosis chiefly occurs in glands th radicles of which are connected with the mouth, pharynx, fauces, c intestine, and they are mostly situated about the jaws or neck, or i the mesentery.

The tuberculosis is characterized by the formation of tubercles which takes place chiefly in the follicular cords. This is accompanied by inflammatory swelling of the gland, just as in other forms of tuberculosis. There is usually a great new-formation of cells which, in the more chronic cases, have mostly the character of epithelioid cells. The amount of swelling and its acuteness vary greatly. There may be a rapid increase of size with redness and other appearances of inflammation, or it may be a slow and indolent process.

Caseous necrosis soon presents itself; at first in a number of centres, but as it proceeds it involves more and more of the gland, and the areas coalesce. The extension of the tuberculosis goes on while the older parts are caseous till the caseous condition comes to involv the whole gland. The completely caseous gland is hard or firm to the touch; it presents on section a homogeneous yellow aspect which has been aptly compared to that of the cut surface of a raw potato. Sometimes at the periphery there is a grey transparent zone representing the still advancing tuberculosis, but the caseous condition may extend to the capsule.

The **Infective character** of the process is manifested by its extension to neighbouring glands. There is sometimes in the neck a complicated tuberculosis of many glands, some lying deeply among the muscles and fasciæ. It is noteworthy, however, that there is little or no tendency to extension through the capsule unless it be first ruptured or destroyed. This accords with the fact that tuberculosis does not usually penetrate connective-tissue membranes.

The caseous condition being thus brought about, the disease, so far as the individual glands are concerned, may undergo certain further developments. The caseous matter may simply remain as dead material, surrounded by connective tissue. It often becomes **infiltrated with lime salts**, and converted finally into a putty-like or stony mass. This is most liable to occur in glands which are protected, such as those of the mediastinum and the mesenteric or other abdominal glands. It is quite common to meet with pultaceous or stony masses in the mediastinum or in the mesentery of adults, which are the obsolete remains of a tuberculosis in childhood.

In the case of superficial glands, which are exposed to mechanical irritation, there is, on the other hand, frequently a **Softening** associated with inflammation. A process akin to suppuration ensues, in which the matter is partly composed of the debris of the caseous matter and partly of pus. The capsule is perforated and the matter passes towards the surface where it opens as a chronic abscess. In its passage it produces a tuberculosis of the parts with which it comes in contact, so that **Tubercular sinuses and ulcers** are frequent results. It is well known that recovery from this condition is only insured by careful removal of all infective material.

Secondary tuberculosis is very common in glands connected with organs which are the seat of local tuberculosis. This applies especially to the bronchial glands which are always secondarily involved in phthisis pulmonalis. The process here is often a very chronic one, and the glands sometimes instead of caseating become indurated as in chronic inflammation. Indeed, in fibroid phthisis the two processes of induration and tuberculosis often go on together. Secondary tuberculosis also arises in the mesenteric and other abdominal glands from tubercular ulcers of the intestine.

The glands are also commonly affected in **General tubercu** They are the seat of small miliary tubercles, and are gen enlarged and hyperæmic.

7. **Syphilitic disease of lymphatic glands.**—This, as we have is a constant result of the primary syphilitic infection, and consti the syphilitic or **Indurated bubo.** The glands slowly enlarge by formation of round cells, and they remain enlarged for mont years. There is little caseous necrosis in the glands, but the conn tissue trabeculæ are thickened. During the secondary stage glands may swell, such as those of the neck.

Gummata sometimes form in the glands in inherited syphili in the late tertiary stage of ordinary syphilis. There is enlarg and, it may be, extension to neighbouring glands. The enl glands may or may not becomes caseous. (See account by Hirschfeld.)

8. **Tumours of lymphatic glands.**—We have already des several forms of new-formation of lymphatic tissue, some of attain to the dignity of actual tumours, and are designated lym or lymphadenoma. There is the leukæmic lymphoma, and the nant lymphoma or Hodgkin's disease, both of which partake character of infective processes.

Of the tumours proper, with the exception of sarcoma, the pr forms are rare but the secondary frequent. **The Myxoma** is times primary and the **Chondroma** has been observed as a seco tumour.

In a case recorded by Virchow a chondroma occurred in the axillary gl connection with a primary tumour of the scapula, and in one by Paget glands of the groin in a case of chondroma of the testis.

The most important form of sarcoma of the lymphatic glands **Lympho-sarcoma,** which is of comparatively frequent occurre the mediastinum (see Fig. 169, p. 336), but is also met with abdomen.

Sarcoma occurs **primarily** as a hard or soft tumour. The form is rare and is usually a fibro-sarcoma. The soft form m a spindle-celled tumour, but is more frequently round-celled. It an alveolar sarcoma. The commoner round-celled sarcoma res in structure the lymphoma and is liable to be mistaken for it, does not present the tendency to spread from gland to gland, its metastasis does not affect the lymphatic system specially. tumours usually grow rapidly, and form large fungating **Secondary** growths frequently form in the lungs. These tu originate chiefly from the retroperitoneal, mediastinal, and bronchial glands. In the alveolar form the new-formation occurs chiefly in the adventitia of the vessels.

Sarcoma does not readily occur **secondarily** in the lymphatic glands, but according to Butlin it does so more frequently than is usually stated. Sarcomas of the foot, tonsils, testicles, and probably the kidney, are liable to affect the lymphatic glands secondarily. The pigmented and softer forms of sarcoma are more likely to affect the glands.

Cancer does not occur as a primary growth in the lymphatic glands but is very frequent as a secondary affection. Cancerous tumours by their irritation may lead to a simple inflammatory enlargement, but, even in those which are very slightly enlarged, there are usually cancerous developments detectable by the microscope. (See further under Cancer.)

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III.—THE SPLEEN.

1. **Structure and formation.**—The exact nature of the function of this organ is somewhat obscure. In order to understand the various changes which it undergoes, it will be necessary to bear in mind certain facts as to its structure. The splenic artery as it enters the organ is accompanied by connective tissue which forms a continuous sheath around its branches. In this sheath there develop at intervals little masses of lymphoid tissue, forming the Malpighian bodies, which are therefore lymphatic follicles closely related to the arterial branches. The arteries break up into capillaries which are mostly distributed in the Malpighian bodies, where they form a somewhat wide-meshed network. At the periphery of the Malpighian bodies the capillaries open

into the splenic pulp, which is, as it were, interposed between the capillaries and the veins. This consists of a honeycomb-like structure, with frequent trabeculæ and meshes (see *e*, *e*, Fig. 387). The meshes contain blood, large cells, and cells containing blood-corpuscles and pigment. The meshwork of the pulp develops occasionally into wider channels or sinuses which are virtually the radicles of the veins. The pulp has a brownish colour both from its pigment and from the fact that it is full of blood. The Malpighian bodies being lymphoid in structure, and sparely vascularized, are whitish in colour. It is clear from this structure that the blood passing into the spleen by the

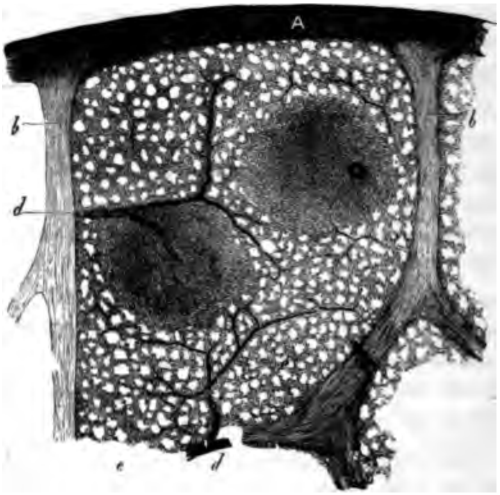


Fig. 387.—Structure of spleen. *A*, capsule; *b*, trabeculæ; *c*, *c*, Malpighian bodies; in that to the right an artery, cut transversely, is seen; *d*, *d*, injected arteries, one running into a Malpighian body; *e*, honeycomb-like pulp. (Kölliker.)

arteries will linger long in the organ, and will especially stagnate the meshes of the pulp. It seems probable that in the pulp the r corpuscles are to some extent destroyed. The existence in the norm spleen of cells containing red corpuscles and pigment seems to indica this. The spleen also probably gives origin to white corpuscles, b it shares this function with the lymphatic glands and the medulla bone, as well as probably with the widely-diffused connective tissu throughout the body. Some have supposed that the spleen also form red corpuscles.

From these remarks it will be understood that the amount of bloo in the spleen will be subject to great variations according as the pul is more or less distended. The pulp forms by far the greatest part o the substance of the spleen, and according as its honeycomb structure is more or less full of blood the size of the organ varies. Thus there is no organ in the body which varies so much in size, even under physiological conditions. During digestion there is an active hyperæmia which causes enlargement of the organ. Again, the capsule and trabeculæ of the spleen are abundantly supplied with smooth-muscle fibre-cells, and its size is influenced by the state of contraction of these. It is well known that by electric stimulation the size of the organ may be diminished, the muscular tissue contracting.

2. **Malformations and Malpositions.**—One or more **Supernumerary spleens** (splenculi, lienculi) are very frequently met with, these being in addition to the ordinary normal organ. They are generally round in form, and have the dark red or blue colour and soft structure of the splenic tissue. They are usually small in size, varying from that of a pea to that of a marble, but cases have occurred in which two spleens of nearly equal size have been present. Sometimes several of these spleens are found usually in the neighbourhood of the normal organ, but they may be away from it, having even been found embedded in the head of the pancreas. Several hundred have been seen scattered about the abdominal cavity.

These accessory organs may be the seat of morbid processes similar to those affecting the spleen itself. This is particularly the case with regard to amyloid disease and tuberculosis. The spleen is also liable to **variations in shape**, some of which are congenital. It is liable to a folding of its convex surface from compression by the ribs in tight lacing. **Alterations in position** are sometimes congenital but may occur during life, chiefly when the organ is enlarged and increased in weight. Again, there may be an unusual length of the ligaments so as to allow of an **undue mobility** of the organ. This also may be congenital, or it may be due to a stretching of the ligaments from increased weight.

3. **Active Hyperæmia and Acute Inflammation.**—We have already seen that an active hyperæmia of the spleen occurs physiologically during digestion. It is met with as a distinctly pathological condition, and frequently in a very exaggerated form in a variety of **acute febrile diseases.** The spleen seems a favourite seat of at least some of the infective agents which have to do with the acute fevers, and this may partly explain the special proclivity to congestion and inflammation in such diseases. Thus the bacilli of typhoid fever and the hæmatozoa of malaria are found in particular abundance in the spleen. Enlargement of the spleen in these diseases forming the **Acute splenic tumour** is often seen in the highest degree in typhus fever, but it

is found also in other specific fevers and in pyæmia, pneumon
diphtheria, erysipelas, etc. In this group of diseases the blood conta
morbid products, and we know that the various parenchymat
organs, the muscles and the glands, are enlarged as a result of clou
swelling, which is to be traced to the condition of the blood. But
enlargement of the spleen is from hyperæmia rather than the res
of a direct tissue change. Consistently with this the enlargement m
be very rapid, so much so that rupture of the capsule may ensue,
observed in some cases of typhus and of intermittent fever. It will
inferred that in this condition the splenic tissue is exceedingly s
sometimes almost diffluent, and the colour of the cut surface is
dark red.

But the condition does not continue as a pure hyperæmia. T
cells forming the honeycomb structure of the pulp enlarge, the blo
vessels and the meshes of the pulp come to contain more round cells
white blood-corpuscles. These are all indications of inflammation, a
a further indication is sometimes afforded by the deposition of fibr
on the capsule of the spleen. The **Malpighian bodies** sometim
undergo enlargement at this stage, but not in all the diseases nam
It is most frequently seen in the later stages of **Typhoid fever** a
Small-pox, and when it occurs the consistence of the organ is firm
than is usual in the acute splenic tumour. At this stage, in wh
more definite inflammatory processes are superadded to the congesti
the spleen is even larger than in the earlier stage, and it may rea
two, three, or even four times the normal size. The organ is undu
soft, and on section may look half-diffluent, although it is firmer th
in the cases without enlargement of the Malpighian bodies. T
colour of the cut surface is considerably paler than in the earlier peri
being more of a greyish or whitish red. On scraping the surface
thick juice is obtained which is not unlike pus mixed with blo
There is not infrequently hæmorrhage in the substance of the sple
so affected, and it may take the form of the wedge-shaped hæmorrha
infarction.

As a general rule the acute splenic tumour diminishes as the prima
disease passes off, and the spleen may be left soft and loose w
wrinkled capsule and unduly prominent trabeculæ. Sometimes th
results a chronic inflammation with thickening of the trabeculæ, b
this hardly occurs unless there have been repeated attacks of hyperæn
as in malarial fevers, and occasionally in typhoid fever.

It is a very rare circumstance for suppuration to occur in the inflam
spleen, but this has been met with in intermittent fever. In such ca
the pus appears in numerous little points which represent the M

pighian follicles, or there is a more diffuse suppuration of the spleen. If the abscesses burst a fatal peritonitis results.

Among the cases of suppurative inflammation of the spleen should be mentioned those in which **Ulcerative endocarditis** or **Pyæmia** is the primary disease. Minute emboli are carried to the spleen as to other structures, and being of a septic nature they each form the focus of an acute inflammation, which has at first a hæmorrhagic character, and afterwards passes on to suppuration. The spleen as a whole is enlarged by active hyperæmia.

4. **The Spleen in Malaria.**—The parasite of malaria seems to exercise a strong local influence on the splenic tissue. There is in acute cases an inflammatory enlargement such as that described above. But in cases where the inflammatory enlargement is repeated frequently, or there is a more continuous irritation of the spleen, we have a chronic inflammation, causing the **Chronic splenic tumour.** This is very common in malarial districts, and is regularly met with in persons who have been repeatedly subject to attacks of ague. But in such districts it occurs even in persons who have had no apparent ague, so that almost every post-mortem examination reveals a chronic **Ague cake.**

The enlargement in ague may depend on a **General hypertrophy** of the spleen, so that the consistence of the organ is nearly normal. There is, however, considerable increase of the lymphoid element, and the trabeculæ are thickened. There is frequently also increased pigmentation. In other cases there is a marked new-formation of connective tissue in the trabeculæ, the pulp is firmer and the blood spaces reduced in size. This condition warrants the designation **Fibrous induration of the spleen.** The organ as a whole is not so much enlarged as in the other form, but it is much firmer and harder, so that the name ague cake is peculiarly applicable here. In extreme cases there is atrophy of the proper constituents of the spleen ; the pulp is much encroached on, and the Malpighian bodies are greatly destroyed. There is usually also much deposition of pigment in the splenic tissue, especially in the pulp, but also to a slight extent in the Malpighian bodies, and in the thickened connective tissue around the vessels.

In both forms of chronic tumour of the spleen the capsule is generally thickened, a condition being thus brought about which is sometimes called **Perisplenitis,** and is analogous to a similar thickening of the capsule of the liver,—perihepatitis (see also under Chronic Peritonitis). The thickening is usually irregular, and we have tendon-like patches or loose shreddy connective tissue on the surface. Sometimes the capsule acquires adhesions to neighbouring structures, and the spleen may be so buried in adhesions as to make it difficult to dissect it out. It is to be remembered, however, that such adhesions are very frequent apart from any proper disease of the spleen at all, being due to inflammations in its neighbourhood. There are, indeed, occasional patches of dense fibrous or cartilaginous consistency occupying the capsule of the spleen, whose origin it is difficult to ascertain, but which are to be regarded as the results of local peritonitis. In most cases of perisplenitis originating outside the spleen the organ is small and atrophied. In some cases the thickened capsule appears to invade the spleen at parts. In these cases the appearances may simulate an old infarction (see Fig. 388). The term *lamellar fibroma* is sometimes applied to such cases of perisplenitis.

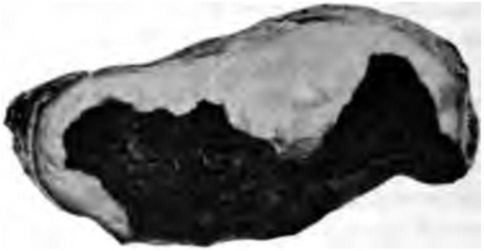


Fig. 388.—Section through a small spleen showing marked perisplenitis. The thickened capsule encroaches on the splenic tissue at one part.

Passive hyperæmia.—This condition occurs in the spleen when the is any considerable obstruction of the portal circulation. Hence w meet with it in cirrhosis of the liver, and in cases of heart diseas which have gone on to general venous engorgement, the hyperæm being, as it were, transmitted through the liver. It may, indeed, occ in consequence of any local or general obstruction whose effects exte to the splenic vein. The organ is enlarged, but not to such an exte as in the acute form. As in cases of passive hyperæmia generally, t connective tissue increases in firmness, and so the whole organ is dens than usual, while the tissue presents a deep red colour. The thickeni of the connective tissue affects the trabeculæ and the sheaths of t blood-vessels.

The embolic infarction.—This is probably of more frequent occu rence in the spleen that in any other organ, except the lungs. W have already seen that this artery and all its branches are end-arteri and that obstruction of one of them can hardly fail to cause the i farction. The infarction has sometimes the hæmorrhagic character, b this is frequently absent except at the marginal parts, and the great part is white or yellow (see Fig. 389). Even when originally red i soon loses much of its colour. The infarction has more or less the form of a wedge with its base at the capsule. On handling the organ it is to be detected by its density, forming a hard mass in the midst of the soft tissue. As a rule, there are several infarctions in the same spleen, and as the embolus in a larger trunk may break up and be distributed irregularly to various branches, we may have very complicated forms assumed by the infarction. For example, it is not uncommon to find the superficial parts of the spleen involved over a large area, while the infarction does not extend much beneath the surface, as if the emboli had been swept into a number of terminal branches near the surface. The spleen, as a whole, is enlarged, the obstruction of the arteries leading to a collateral hyperæmia by dilatation of those remaining open. This enlargement may reach considerable dimensions. On the capsular surface of the infarction there is often a deposition of fibrine, and it is interesting to know that during life the existence of this has been sometimes diagnosed by the discovery of a friction sound.

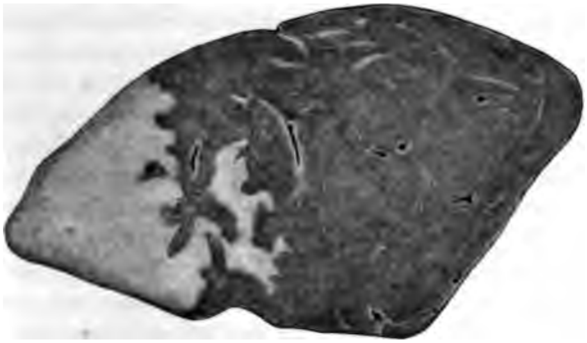


Fig. 389.—Infarction of spleen. The pale wedge-shaped area to the left contrasts with the darker normal tissue of the organ.

The affected area of splenic tissue is in a state of coagulation-necrosis and presents the usual characters of that condition, chiefly the absence of nuclei when the tissue is stained. The blood-colouring matter is dissolved out, being partly absorbed and partly deposited in solid granules throughout the infarction or at its marginal parts. Around the infarction a chronic inflammation occurs with the usual new-formation of granulation tissue which eats into the infarction (see Fig. 390). As the infarction becomes absorbed, the connective tissue which develops from the granulation tissue draws together, the final result being a cicatrix in which some cheesy matter may be found representing the original infarction. During these processes the spleen gradually returns to its normal size and condition, with, it may be, some thickening of the capsule. We frequently meet with one or more cicatrices in the spleen from old embolism. These are always visible at the surface and penetrate inwards, but usually they have little depth.

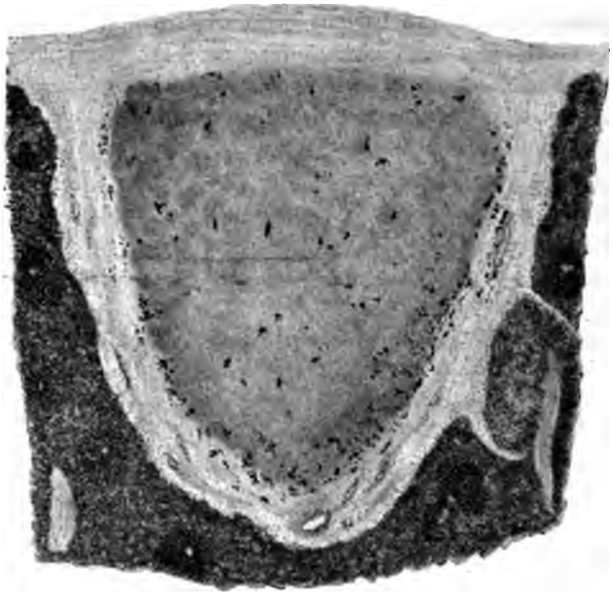


Fig. 380.—Infarction of spleen. The pale infarction surrounded by fibrous tissue is shown. A large amount of pigment is present in the infarction, especially at its periphery. × 15.

The condition of the spleen in **Leukæmia** has been already describe but it may be recalled that in this disease the spleen is often eno- mously increased in size, and may weigh 40 pounds. The condition malignant lymphoma or **Hodgkin's disease** has also been describe

Rupture of the spleen.—This occurs occasionally, as we have see in acute enlargements of the organ. Traumatic rupture is mu more frequent. This is effected by blows or falls on the abdomen, a also by injuries to the chest in which the lower ribs are forced agai the organ. There may be considerable rupture without any exter marks of injury. It is important to remember that the enlarged a hard spleen is more liable to rupture than the normal one, both account of its more brittle character and its size. This is important i a medico-legal aspect, especially in malarious districts. The ruptu may lead to fatal hæmorrhage, but as the lesion is often associated with other injuries, the bleeding only plays a part in the result. On the nd, the hæmorrhage may be slight, and the wound may heal e a cicatrix.

erative changes.—Of these by far the most important is l or **waxy disease.** It has already been mentioned that the more frequently the seat of this disease than any other organ, it appears in a majority of cases to be the organ primarily There are two forms of amyloid disease, called respectively **form** and the **Diffuse form** r spleen, to which a third oined form may be added. **first** the Malpighian bodies **ly involved**; in the second . We are entirely ignorant onditions which induce these ses in the situation of the ation, but it may be said e **sago** spleen is peculiarly hich occurs in phthisis pul-, while the waxy form occurs ilis.

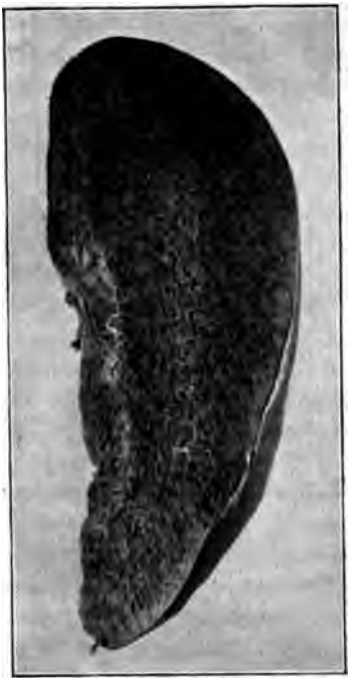


Fig. 391.—Sago spleen.

Sago spleen is a moderately l organ. On section we on the cut surface, instead normal small Malpighian transparent glancing areas ave been very aptly compared ıs of boiled sago. These are over the surface in great pro- see Fig. 391). On applying on of iodine the affected areas ut as brown spots, which become of a deeper colour on adding sulphuric acid. Microscopic sections (see Figs. 392, 393) show rent hyaline areas of circular outline and larger or smaller size, large that they are continuous with one another at the peripheries 92). These areas represent Malpighian bodies, whose normal re, when the disease is advanced, is entirely replaced by a homogeneous transparent material. In the early stages, how- he addition of methyl-violet or iodine brings out a beautiful k in the Malpighian body, and it is obvious that the reticulum attacked (Fig. 393). The lymphoid corpuscles disappear as robably by atrophy on account of the pressure of the affected ım. The arteries whose lymphoid bodies are thus affected are often themselves degenerated, but they may remain unaffected. advanced stages of the disease the enormous enlargement of Malpighian bodies causes atrophy of the pulp, and we may have

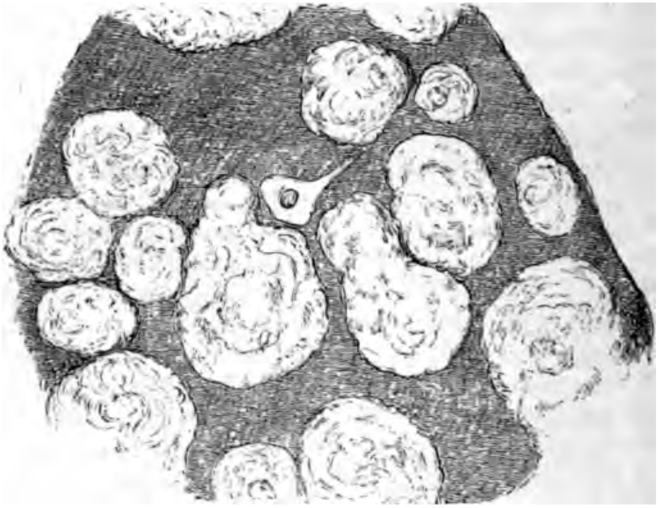


Fig. 392.—Diagrammatic sketch of a section of a sago spleen. The enlarged and translucent Malpighian bodies are seen as they appear in the unstained condition. × 20.

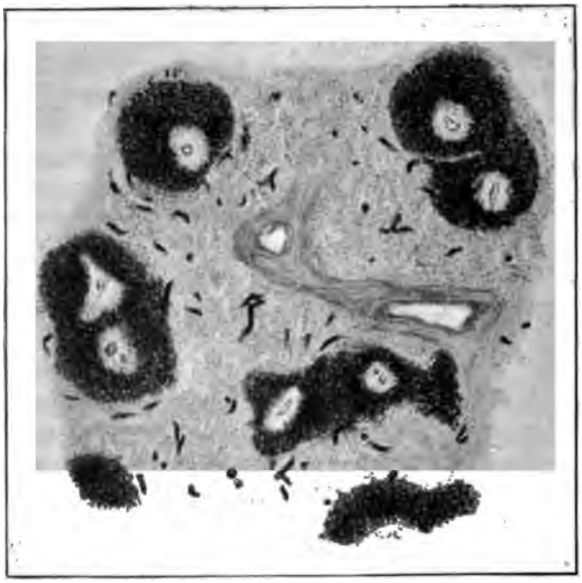


Fig. 393.—Sago spleen. Methyl-violet preparation. The Malpighian bodies and vessels are affected. × 20.

spleen presenting little beyond large round, sago-like bodies. The pulp may, however, itself take part in the amyloid disease at the periphery of the Malpighian bodies.

The Diffuse amyloid or waxy spleen presents much greater enlargement than the sago form. It is in the highest degree hard and heavy, and the edges rounded. On section the tissue seems homogeneous and inelastic, and of a dark translucent appearance, which has been compared to that of wax or bacon, hence the names Waxy and Lardaceous spleen, which are most appropriately applied to this form. The degeneration affects the greater part of the spleen, but there may be islands of normal pulp visible. The Malpighian bodies are hardly visible, and the cut surface has a smooth uniform appearance. The application of iodine produces a general deep brown coloration of the tissue. Under the microscope (as shown in Figs. 394 and 395) it is seen that the walls of the sinuses of the pulp are involved. On account of the greater density of the amyloid material the honeycomb structure of the pulp is often brought out in a much more striking manner than is possible in a normal spleen. This is more marked if the sections be stained with methyl-violet, the trabeculæ assuming a bright colour and becoming very distinct (Fig. 395). In the later stages the appearance is more uniform, but indications of the trabecular arrangement may still be visible. By the enlargement of the pulp the Malpighian bodies are greatly atrophied, but they may show traces of amyloid disease. In this form the walls of the arteries and veins are usually affected by amyloid degeneration.

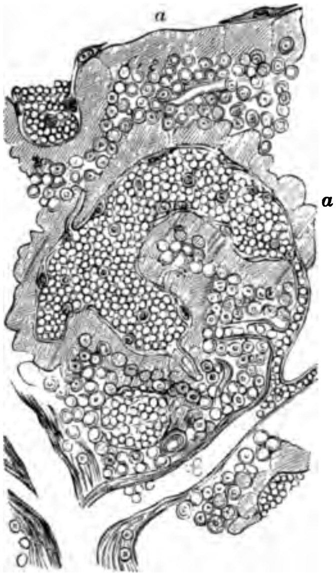


Fig. 394.—Diagrammatic sketch of a diffuse amyloid spleen. The swollen and translucent tissue of the pulp (*a*) is shown. ×400. (After KYBER.)

Infective and other tumours of the spleen.—Tuberculosis does not occur in the spleen as a primary disease, but in acute general tuberculosis we frequently find tubercles in great abundance (see Fig. 396). The tubercles are usually seated in the neighbourhood of arteries, and are often difficult to distinguish from the lymphoid Malpighian bodies which have a similar seat. The existence of the

giant-celled structure and the tendency to caseous degeneration wi
assist in distinguishing them (Fig. 67, p. 194). Occasionally we me
with **large caseous masses** in the spleen, which may reach the size

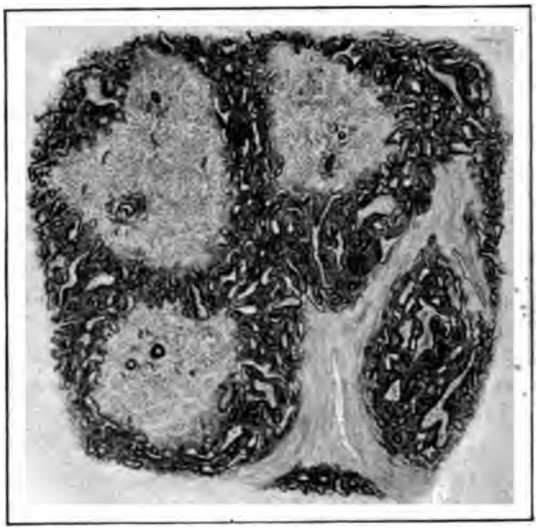


Fig. 395.—Diffuse waxy spleen. Methyl-violet preparation. The walls of the vascular sinuses are specially involved. The reticular structure is manifest The Malpighian bodies are unaffected, although some of the vessels in their midst give the amyloid reaction. × 20.

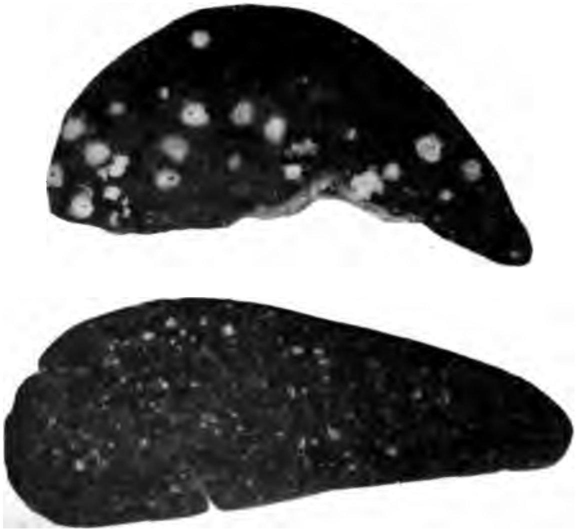


Fig. 396.—Caseous tubercles in the spleen. From two cases of chronic general tuberculosis.

'alnuts. These occur mostly in children who are the subjects of uberculous disease of the lymphatic glands of the abdomen. The eneral distribution of the nodules suggests that the infective material as been carried by the blood, and in some cases there may have een a rupture of a softened gland into the splenic artery. **Syphilitic ummata** are rare in the spleen, and have been met with chiefly in ongenital cases. In Hodgkin's disease the spleen is generally the eat of new-formations, and there is usually great enlargement of he organ (see p. 220).

Tumours proper are equally rare, but cases of **Fibroma, Sarcoma,** ind cavernous **Angioma** have been observed. **Cysts,** which may e unilocular or multilocular, are of occasional occurrence in the pleen. Small cysts with clear contents are occasionally met with in onsiderable numbers towards the surface of the organ, and probably irise by inclusion of portions of the peritoneal endothelium. Sar-omas occur secondarily in the spleen with greater frequency than ny primary tumour, and this is especially true of melanotic sarcomas, rhich may possibly originate in the spleen. **Secondary cancers** are are even in cases where a generalization of the cancer has occurred y the blood. Extension may occur from the peritoneal surface into ie spleen in cases where, from cancer of the stomach or elsewhere, ie peritoneum is involved. Small whitish-yellow globular bodies of ird consistence are not infrequently met with. They are obviously lated to the trabeculæ, and are probably to be regarded as phleboliths. **Parasites** are very unusual in the spleen. The **Echinococcus** is most common, forming hydatid cysts, sometimes of large size. **ntastoma denticulatum** is of occasional occurrence.

iterature.—Heinrich, Die Krankh. der Milz.; Birch-Hirschfeld, Arch. d. ilk., xiii., 389, and Lehrb.; Rolleston, in Allbutt's System of medicine, vol. iv.; edreich, Acute splenic tumour, in Volkmann's Samml., Syd. Soc. transl., 2nd ies, 1877; Mosler, Zeimssen's Encycl., 1878, viii.; Prenner, Gewicht der Milz verschied. Krankh., 1885; Albrecht (accessory spleens), Ziegler's Beiträge, ; Heusinger, Entzünd. d. Milz, 1823; Moxon (Abscess in ulcerative endocar-is), Path. Trans., xix., 198; Bright (Chronic splenic tumour), Guy's Hosp. Rep., ; Kyber (Amyloid disease), Virch. Arch., lxxxi., 1880; Wichmann, Ziegler's iträge, xiii., 1893; Langhans (Cavernous tum.), Virch. Arch., lxxv., 373; Spill-nn (Cystic hæmatoma), Arch. d. Phys., 1876, 419; Renggli, Ueber multiple sten der Milz, Zürich, 1894; Thornton (Multilocular cyst), Path. Trans., xxxv., 84; Weichselbaum (Sarcoma), Virch. Arch., lxxxv., 562; Baumgarten (Syphilis), irch. Arch., xcviii.; Bastian (Hydatid cyst), Path. Trans., xviii., 257.

SECTION III.

DISEASES OF THE BONES AND JOINTS.

A. **The Bones.**—Introduction as to development and structure. I. **Some Affections of the Bone Marrow.** II. **Malformations.** III. **Rickets, Cretinism,** etc., a disease of growing bones, caused by general ill-health. Character of lesions at ossifying cartilage and under periosteum; Deformities due to rickets in long bones, chest, vertebræ, pelvis, head. Recovery. IV. **Retrograde changes,** (1) Atrophy; (2) Osteomalacia or Mollities ossium. V. **Inflammations**—Introductory. (1) Acute and suppurative inflammations, traumatic and infective, the latter important; (2) Chronic inflammations, implying rarefaction and new-formation. VI. **Hypertrophy.** VII. **Necrosis**—Causation. The resulting lesions mainly inflammatory; separation of sequestrum absorption of dead bone. Phosphorus-necrosis. VIII. **Regeneration.** (1 Healing of fractures; production and structure of callus. (2) Transplantation of bone. IX. **Specific new-formations.** (1) Tuberculosis; causation; lesions including caries, cold abscess, etc.; healing of lesions. (2) Syphilis; gummata and lesions of congenital syphilis. (3) Actinomycosis. X. **Spinal curvatures**—Introduction. Forms of curvature, antero-posterior or lateral XI. **Tumours,** chiefly exostoses and sarcomas.

B. **The Joints.** I. **Dislocations and Misplacements,** congenital forms; talipes traumatic and spontaneous dislocations. II. **Anchylosis.** III. **Inflammations** IV. **Syphilis and Tuberculosis.** V. **Loose bodies.**

A.—THE BONES.

INTRODUCTION.—Bone differs materially in structure and function from most of the other tissues of the body, and these peculiarities exercise an important influence on the pathological changes to which it is liable.

The Bone-marrow.—This structure seems to subserve a double function in the economy. In the period of development and growth it is actively engaged in the building up of the skeleton, and even in the adult it contains structures capable of renewing the process of bone-formation. On the other hand, it is evidently an organ intimately related to the formation of blood, and this function, though most active during development and growth, is retained in the adult state.

The bone-marrow as a blood-forming organ.—Much attention has been paid of late years to the bone-marrow as intimately related to the formation and replenishment of the red blood-corpuscles. The spaces left by the solid and rigid structures of the bone are not entirely taken up by the blood-vessels designed to nourish the bone, but nature has taken advantage of them to hold tissue having the function mentioned. This matter has already been referred to in the General Part of this work.

The normal bone-marrow is divisible into the **Red marrow** and the **Yellow** or **Fatty marrow**. The former is found in the fœtus in all the medullary spaces, whether the hollows of the shafts of the long bones or the cancellated tissue. As the child becomes older it is replaced by yellow or fatty marrow in the shafts of the long bones and even in the cancellated tissue of these, but in the adult it remains in most of the cancellated tissue of the short and flat bones. The red marrow is the active tissue in relation to the blood. The yellow marrow is largely adipose tissue, and it replaces the red marrow as the requirements of blood-formation become limited. In the fœtus and growing child there is a great new-formation of blood, both to replenish the loss incident to the processes of life and to increase the actual amount in proportion to the increase in the tissues. As the adult period is reached the latter requirement diminishes and disappears, and yellow marrow takes, to some extent, the place of the red marrow. Even the yellow marrow is not a pure adipose tissue, as the constituents of the red marrow are still distinguishable in it, although sparsely present, and there may be, under pathological conditions, a partial or complete return to the condition of the red marrow.

The red marrow is a highly cellular and highly vascular substance. The cells are of various sorts. There are larger and smaller colourless cells, the marrow cells or myelocytes. Many of these contain neutrophil granules in their protoplasm (*neutrophil myelocytes*) while others contain large eosinophil granules (*eosinophil myelocytes*). Further, there are cells of a yellowish colour like the red blood-corpuscles, but which, unlike these, are nucleated. The nucleated red cells (*erythroblasts*) are regarded as concerned in the formation of the red blood-corpuscles, and they present the appearances of nuclear division by karyokinesis. The capillaries and veins of the red marrow are wide and thin-walled; some authors have even stated that they do not possess proper walls, but are bounded directly by the marrow cells.

Formation and growth of bone.—During the period of growth bone is in a condition of great activity, the growth of bone being effected by processes which are, in some respects, special and peculiar. The proper bony tissue (*tela ossea*) is composed of a rigid calcified matrix, enclosing the living cells or bone-corpuscles in lacunæ. This tissue onc formed is, like the mason-work of a house, fixed in form and insu ceptible of expansion or plastic alteration in shape. It can only b altered by being taken down and rebuilt. But in the growing bon there is necessarily a very active process of reconstruction going o The bone as a whole is expanding, and this is effected, not merely b apposition of new bony tissue to the old, but by a process involvin destruction and reconstruction.

The Internal architecture of the bones is of great interest both fro a physiological and pathological point of view. From the observatio of Meyer, which have been amplified and expanded by Wolff, it appea that the bones are carefully constructed with a view to the function resisting the mechanical forces of pressure and traction. Pressure mainly exercised at the articular ends of the bones, and the cancellat tissue existing there consists of series of trabeculæ which arch in vario directions so as to carry the weight. These trabeculæ mostly end the dense bone of the shaft or otherwise, which thus becomes t ultimate repository of the pressure. This elaborate architecture preserved during the process of growth, and this can only be effect by gradual destruction and reconstruction.

It is a further point of much interest that when the normal archit ture of the bones is interfered with by imperfectly adjusted fractur by bendings, or by dislo tions of the bones, there a reconstruction so as meet the new lines of pr sure which are thus broug about. Thus even in t adult there is a moulding the affected bones accordin to a definite plan. Wher in the new form of th bone, the pressure is in creased in any particula direction, new-formation o bone occurs along the line of increased pressure, whilst absorption occurs in places where th pressure is diminished. Thus in the annexed illustration from a cas of genu valgum or knock-knee (Fig. 397) it is seen how the head of th right tibia shows a marked increase in the trabeculæ under the out condyle, along with a corresponding thickening of the shaft, due to th

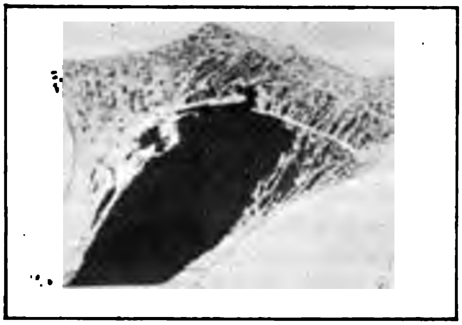


Fig. 397. Head of right tibia from genu valgum. There is great thickening of the bony trabeculæ on the outer side. (Wolff.)

fact that, in the faulty position of the leg the pressure was much greater on the outer than the inner condyle. The extent to which reconstruction is necessary is emphasized when one remembers that the shaft of a young child's femur is no greater in diameter than the medullary cavity of that of an adult. In fact, in the course of growth the whole bone is, in many cases, taken down and reconstructed several times over.

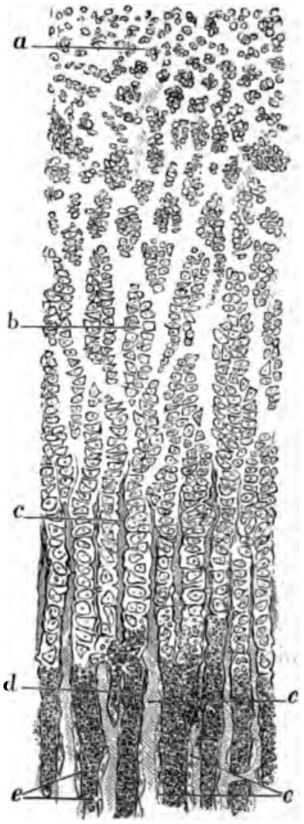


Fig. 398.—Longitudinal section of bone ossifying from cartilage: *a*, commencement of proliferation of cartilage cells; *b*, cells arranged in longitudinal groups; *c*, matrix of cartilage impregnated with lime, this calcified matrix is continued beyond the ossifying border (*c* on right side); *d*, medullary spaces containing round cells replacing cartilage cells; *e*, *e*, formation of bone at borders of calcified matrix, the osteoblasts each forming a piece of bone and remaining as the bone corpuscle. × 90. (After THIERFELDER.)

The growth of bone is effected by the process of **Ossification**. In a longitudinal section of a growing long bone, such as that illustrated in Fig. 398, the process of ossification from cartilage may be seen.

At the upper part of the figure (*a*) there is the normal appearance of hyaline cartilage. As the ossifying margin is approached the cells multiply, and at first they form irregular groups, as at *b*. Nearer the margin the multiplying cells become arranged in rows parallel to the long axis of the bone, the elongated groups being separated by narrower elongated pieces of hyaline matrix. The beginning and the end of this zone of multiplying cartilage cells are quite abrupt, and form nearly straight transverse lines. This zone appears to the naked eye as a narrow bluish band. Next occurs an infiltration with lime salts of the hyaline matrix between the groups, the matrix becoming opaque and granular (*c*, *c* in figure). This forms a yellow zone as seen with the naked eye. This zone is also suddenly interrupted, and at a definite level the groups of cartilage cells give place to cavities filled with **Fœtal marrow**, consisting of round cells and blood-vessels (*d*). It is from these cells that the formation of true bone occurs. The cells contained in the spaces have the power of producing bone, and are hence called **Osteoblasts**. These fix themselves to the walls of the cavities, which, as we have seen, are composed of calcified cartilagino matrix, and each cell forms around itself a certain portion of bo tissue, apparently by a process of secretion. The *tela ossea* thus form encloses the cell which has formed it, and the latter remains as a bo corpuscle. In such a section as that under review one constantly se at the borders of the cavities layers of osteoblasts with oval areas new-formed osseous tissue around them, *e* in figure. Thus the calcifi cartilaginous matrix is encroached upon, and the bone is formed.

Besides this ossification from cartilage, we have what is commo but not quite correctly called Ossification from membrane. In all su cases we have cells similar to those in the cavities mentioned abo which have the characters of osteoblasts, and form bone in a simi fashion. These osteoblasts form a layer under the periosteum, th exist also in the spongy parts of bones, and at the ossifying margins flat bones.

The **Absorption of bone** is effected by active cells which are tinguished by the name of **Osteoclasts.** The giant-cells or my plaques which exist in fœtal bone-marrow have this function. Wh absorption is going on these cells are found attached to the bo and lying in gaps evidently formed by them and called Howsh lacunæ.

When the period of growth is finished, the osteoblasts and the ost clasts have completed their work, but the bone remains penetrated every part by soft tissue. This soft tissue, as we have seen, subser blood-formation, but it also contains the remains of the structu which were concerned in the building up of the bone. We may acc the view of Ranvier, according to which the bone in the adult state enveloped in, and penetrated by the remaining potential osteobla This tissue constitutes the bone-marrow and the internal layer of periosteum (called *Periosteal marrow* by Ranvier), while between th two there is a connecting network traversing the Haversian canals.

From these observations it appears that in childhood the bones in an extraordinary state of activity, a process of enlargement a reconstruction continually going on. At the same time, the functi of the bones as substantial props is in full activity. It is not remar able, therefore, that in childhood the bones are peculiarly liable disease, which may take origin from without or be due to inhere weakness.

In the diseases both of children and adults again, there may be partial return to the conditions of the period of growth, and osteobla and osteoclasts resume their operations, the processes being now path logical.

Another characteristic of pathological processes in bone is the occurrence formerly alluded to, of **Metaplasia**. Bone, cartilage, and connective tissue are fundamentally the same tissue, and apparently the same cells may be, according to circumstances, osteoblasts, fibroblasts, or chondroblasts. This will be illustrated under Fractures.

Literature.—Quain's Anat., 10th ed., vol. i., p. 268, 1891; Meyer, Die Architectur der Spongiosa, Reichert and Du Bois-Reymond's Arch., 1867, and Jubiläumsschrift für von Bischoff, 1882; Wolff (who scarcely does justice to Meyer), Centralbl. f. d. med. Wissensch., 1869, Virch. Arch.; l., 1870, and Das Gesetz der Transformation der Knochen, 1892; Ranvier, Le développement du tissu osseux, 1865; Schmidt, Lubarsch and Ostertag, Ergebnisse, iv. 1899, v., 1900.

I.—SOME AFFECTIONS OF THE BONE-MARROW.

The bone-marrow as a blood-forming structure is intimately concerned in diseases in which the constitution of the blood is altered. Most of these conditions have been already considered under Pernicious anæmia and Leukæmia. They consist chiefly in a transformation of the yellow marrow in the situations where it occurs either into a red marrow such as occupies the medullary spaces in the fœtus, or into a white or yellow lymphoid marrow whose structure resembles that of lymphatic glands (see under Leukæmia). With this transformation there is sometimes atrophy of the bony lamellæ so as to give more space for the accommodation of the altered marrow.

Besides these lesions, the bone-marrow is liable to lesions in acute infective diseases, these lesions somewhat resembling those of the spleen. There is hyperæmia and there are sometimes hæmorrhages which may take the form of infarctions. According to Golgi, the bone-marrow in hæmorrhagic small-pox shows everywhere diffuse hæmorrhages.

In old age the adipose tissue of the marrow is liable to undergo diminution, and its place is taken by a **Gelatinous substance** which is scantily cellular. The same condition is met with in chronic diseases such as tuberculosis, chronic Bright's disease, etc.

Literature.—Neumann, Arch. d. Heilk., x. and xi., Centralb. f. d. med. Wissensch., 1882, p. 321; Golgi, Rev. clin. di Bologna, 1873; Ponfick, Virch. Arch., lvi., lx.; Chiari (Small-pox), Ziegler's Beiträge, xiii.; Geelmuyden (Historical account and literature as well as independent observations), Virch. Arch., cv., p. 136; Muir, Trans. Path. Soc. Lond., xliii., 1902.

II.—MALFORMATIONS OF BONE.

The more important malformations of bone are connected with general malformations, and have been considered in an earlier part.

We have defects of the skull in anencephalus, and of the vertebræ in spina bifida.

Besides these, we have congenital reduplication of bones, such as of the vertebrae, the ribs, the fingers, and toes. **Supernumerary vertebræ** are met with in any of the regions of the column. **Supernumerary ribs** may be cervical or lumbar. In **Supernumerary fingers and toes** the bones may be absent, or may be represented only by cartilage.

Certain **Malformations of the skull** have been ascribed to prematur coalescence of the bones at the base, or of the sutures of the cranium, condition designated **Synostosis**. The basilar parts of the occipital an sphenoid bones are formed from cartilage. The basilar part of th sphenoid is originally in two parts, presphenoid and postsphenoid which unite before birth. The sphenoid and occipital bones ar separated by cartilage up till the twentieth year, and as this cartilag has the characters of ossifying cartilage, on it the growth in length the base of the skull depends. A premature synostosis of these tw bones will check growth and lead to a **Shortening of the base** of th skull. To this is ascribed the existence of abnormal retraction of th nose.

The bones of the calvarium grow at their margins, or, in other word at the sutures. A premature coalescence of the bones or **Closure the sutures** will stop this growth. According to the sutures affecte the result varies. If all the sutures close there will be a gener smallness of the head, a **Microcephalus**. If there be a prematu synostosis of the coronal and lambdoidal sutures, the growth in leng is checked, and, as a compensatory growth in breadth occurs, the head abnormally wide and flat on the vertex, conditions designated by t terms **Brachycephalus** and **Platycephalus**. When the sagittal sutu is affected, growth in breadth is interfered with and an abnormal long cranium is produced, a **Scaphocephalus**.

There seems no doubt that microcephalus arising in this way m lead to arrest of the growth of the brain, some cases of idiocy bei thus explained. On the other hand smallness of the brain will associated with smallness of the skull, but this will not be associat with premature synostosis.

A similar **Synostosis of the sacro-iliac articulation** may lead permanent malformation of the pelvis. If the synostosis occur on o side the sacrum is defective in its lateral mass and the ilium is al imperfectly expanded. These parts being shortened, the ilium has straighter course from sacrum to symphysis, and the pubic bone of th affected side joins the opposite one at an angle. The pelvis is thu narrowed on the one side. If the synostosis is on both sides, then both iliac bones have a shorter and straighter course, and the pelvis has a more quadrilateral form than normal, and is narrowed transversely.

Literature.—VIRCHOW, Ges. Abhandl. (with classification of forms of skulls), 1856, p. 901; Entwickel. des Schädelgrundes, 1857; Würzburger Verhandl., vii., 1857; Virch. Arch., v., xiii., and xciv.; LITZMANN (Synostosis in pelvis), Arch. f. Gyn., xxv., 1884.

III.—DISEASES OF THE DEVELOPING BONES, RICKETS OR RACHITIS, CRETINISM.

Causation of rickets.—This disease occurs in children during the earlier periods of growth, and so far as the bones are concerned it is a disease of development, the normal process of ossification being interfered with. Cases have been observed of congenital rickets, but these are rare, and in the majority of cases it begins in the first or second year, its commencement being very rarely delayed beyond the fourth or fifth year. In a large proportion of cases its onset seems to be in the latter half of the first year or the first half of the second.

An endeavour has been made to make out that rickets is merely a manifestation of hereditary syphilis, but this view has not received acceptance in this country. It has been pointed out again and again that rickets is very common in cities where syphilis is uncommon. In the city of Glasgow, for instance, rickets is very common among the poorer classes, but syphilis is relatively uncommon. It is so also in Aberdeen, Edinburgh, Belfast, and elsewhere. We shall see afterwards that syphilis produces changes in the bones in some respects analogous to rickets, and atrophy of the cranial bones, sometimes designated **Craniotabes**, although formerly regarded as rachitic, is probably in most cases syphilitic; the two diseases, however, are essentially distinct.

Rickets occur amongst children who are injudiciously fed and badly housed, and the disease in the bones is to be regarded as part of a general loss of health. The body is weakened, and, besides the bones, other parts suffer. According to Macewen, it supervenes in a considerable number of cases on an attack of one of the acute fevers, as measles or scarlet fever, such an attack leaving the child in an ill-nourished condition. There are usually symptoms of indigestion and intestinal catarrh, sometimes with fever, and in a certain proportion of cases there is enlargement of the spleen and sometimes also of the liver and lymphatic glands. The bones, being the most actively growing parts at this period of life, are, however, specially affected.

Rickets, or a condition analogous to it, has been produced artificially in growing animals by feeding them with small doses of phosphorus, or by giving them lactic acid, by the mouth or subcutaneously. In both cases the diet must be deficient in lime salts. In the latter case it has been supposed that the lactic acid, being a ready solvent of lime, prevents its deposition in the bones, and it has been inferred that in the human subject gastric derangement causes the formation of an excess of lactic acid, which is the cause of the disease in the bones. There is, however, the objection to this view, that rickets is not always accompanied by any considerable gastric disorder, and such a view does not explain its occasional occurrence in the fœtus. Besides, the disease is clearly an error in development, and were it due merely to absence of the lime salts, we should expect the bony matrix to be formed without the lime salts. The very opposite frequently occurs: we have often an impregnation of the cartilage with lime salts, a calcification of the cartilage (see Fig. 399, *b*, *b*), while true ossification lingers. Rickets can, in most cases, be cured by supplying sufficient food and proper lodging, and this points to its origin in the opposite of these.

Character of lesions.—The lesions in rickets may be summed up in the statement that the preparatory stages of ossification are exaggerated, while the completion of the process is delayed.

At the ossifying cartilaginous border the conditions may be studie by examining Fig. 399, and comparing it with Fig. 398, which represent normal ossification, both figures possessing a similar degree of magn fication. The most pronounced difference from the normal is th enormous exaggeration of the zone of multiplication of the cartilag cells (*a*, *a*). The groups of cells are in much larger numbers an occupy a much greater space; at the same time they have not alwa the normal arrangement in rows parallel to the long axis of the bon The cells of the groups also vary considerably in size. In the norm bone the cells in the deepest part of this zone are large, but in ricket while some are large, as at *b*, there are others even at the same lev or deeper, of small size.

Next, in regard to the zone in which the cartilaginous matr becomes calcified, this also is represented here in the most irregul fashion. Calcification of the matrix and of the cartilage cells (as *b* on left) occurs, but it is very irregular. Thus calcification of t cartilage may be seen high up, as at *b*, while numerous groups low down remain uncalcified. In many cases also, whether calcified not, the cartilage cells lose to a considerable extent their characteris grouping (as below *b* on left).

Then as to the formation of medullary cavities and development bone, the figure shows how irregularly this occurs. Blood-vess appear with considerable frequency in the midst of the cartilage, a towards the deeper parts there are medullary spaces with osteoblasts them. These may even be seen forming new bone, as at *d*. But t medullary cavities do not occur with any greater regularity than t other stages in the process, and it is not always apparent that th

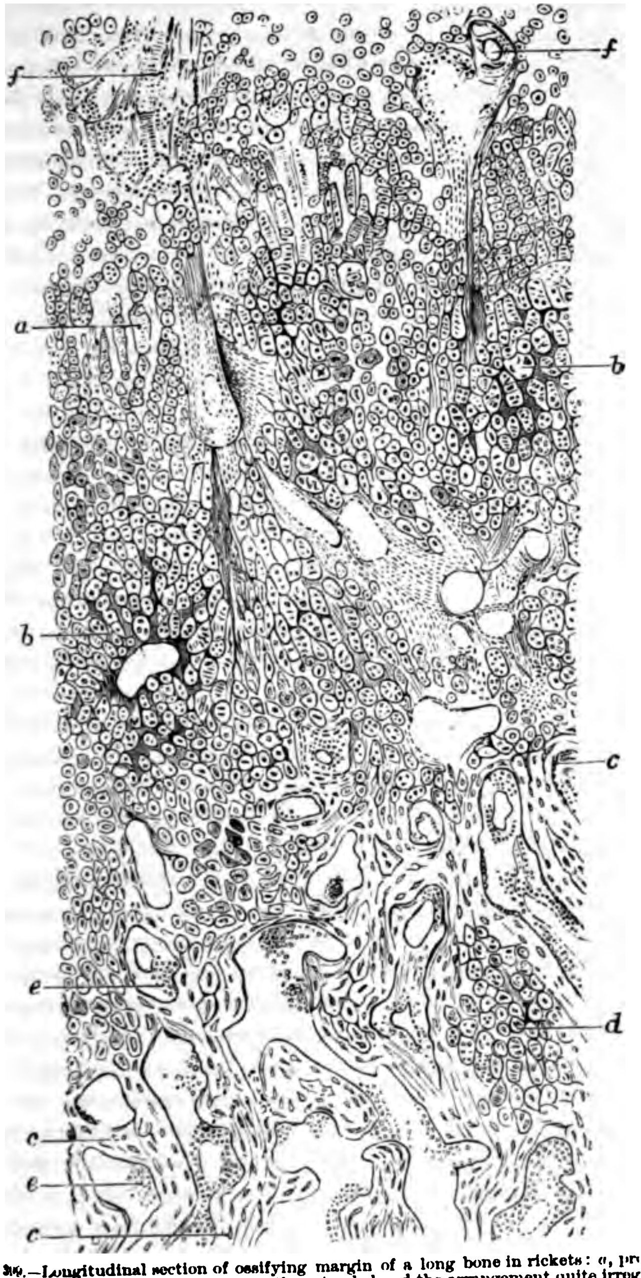


Fig. 309.—Longitudinal section of ossifying margin of a long bone in rickets: *a*, proliferating cartilage cells, the area of these very greatly extended and the arrangement quite irregular; *b*, *b*, calcification of the cartilaginous matrix at different levels, but not followed by formation of medullary cavities. The formation of medullary cavities (*e*, *e*) and of bone is occurring quite irregularly, the level being higher *at the right* (*c*) than at the left (c). At d the osteoblasts are forming bone. *In various places, especially at d*, pieces of cartilage are seen in the midst of bone, *and an apparent transition of the one into the other is seen.* × 90. (Thierfelder.)

have to do with the formation of the bone. It will be seen in the figure that at a certain somewhat indefinite level, which is lower at the left side than at the right, bony trabeculæ appear (*c*, *c*). But it will also be seen that the bone is directly continuous with cartilage, the difference in the two being indicated chiefly by the difference in the cells. It appears also that in the cartilage, which is thus immediately continuous with the bone, the individual cartilage cells are separated by a matrix just as the bone corpuscles are (see figure). In fact there is here a conversion of cartilage into bone, and there are even appearances suggestive of the gradual transformation of cartilage cells into bone corpuscles. It will be seen in various places, but especially at *d*, that pieces of cartilage survive in the midst of the new-formed bone. Such cartilage may be calcified or not.

To the naked eye the changes described above are indicated in a longitudinal section of a rickety long bone. The blue zone, which forms a straight narrow transverse line in the normal bone, is here greatly increased and its boundaries are irregular. The yellow zone of calcification of the cartilage is still more irregular, and yellow pieces crop up in the midst of the blue zone. Blood-vessels appear also at different levels. In the area of the blue zone the cartilage is greatly swollen, as the enormously multiplying cells take more space than normal.

Under the periosteum the normal thin layer of osteoblasts is increased till it forms a layer of considerable thickness. Bone is formed to a very limited extent and very imperfectly, so that instead of a proper dense bone, such as should be formed on the surface of the shaft, there is a loose irregular spongy bone. But even the trabeculæ of this spongy bone are not properly formed. Immediately under the thick subperiosteal layer the new-formed bone does not show in its matrix the homogeneous character of the matrix of bone; it is granular, and the lime is obviously deposited without combining with the matrix in the normal manner. It is a calcification rather than an ossification, and the trabeculæ are rather osteoid than osseous. On passing inwards the tissue becomes more strictly osseous however, although hardly acquiring the regular arrangement of the dense bone of the shaft.

Corresponding with the structure described are the naked eye characters. The subperiosteal layer is seen in the form of a red vascular layer of some thickness. This is so obvious in some cases that, at one time, it was described as if a blood-clot were formed under the periosteum. Beneath this the spongy character of the bone can be seen, while the shaft is considerably thicker than normal and obviously more easily bent.

Deformities of the bones due to rickets.—In considering the deormities so often produced by rickets, it is to be remembered that he two chief changes in the bones are, in the first place, enlargement nd softening of the epiphyseal extremities of the bones from the ffection of the cartilage, and in the second place, thickening with ss of resistance of the shaft from the periosteal lesion. These conitions do not always go strictly parallel, one or other being frequently he more prominent in a paricular bone. The various bones f the body also present very ommonly different degrees of ickets, although the disease, eing a general one, usually ffects many bones. Even in ones affected to a similar exent, however, the resulting deformities present very great variations: the deformities consist largely of curvatures of the bones from the application of external forces and the bones are differently placed in relation to such forces.

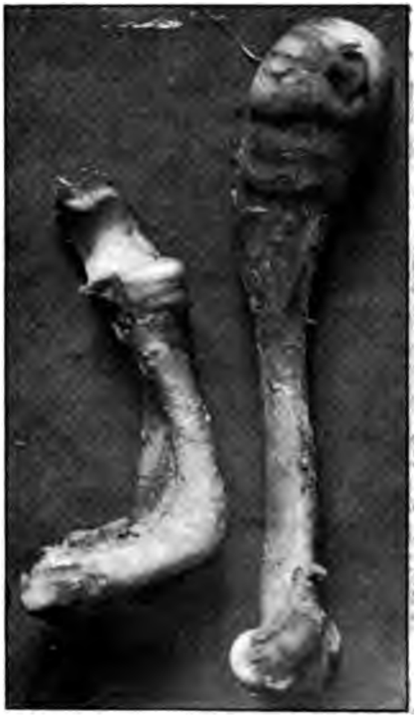


Fig. 400.—Humerus and radius and ulna in rickets. The humerus is much swollen in its upper parts. The bones of the fore-arm are much bent.

Deformities of the long bones.—The most obvious change at the outset is **swelling of the cartilaginous ends** (see Fig. 400) of the long bones, giving a clubbed or knobbed appearance to the limbs. This is common to all the long bones, and is the condition generally taken in practice as evidence of the existence of the disease. The bones are also arrested in their growth, so that they are stunted while at the same time they are unduly thick.

The remaining deformities occur in the majority of cases in the lower limbs, and are the result of the **weight of the body** acting on the bones in their weakened condition. Similar deformities are met with in the **bones of the arms** (see Fig. 400) in cases where external force is frequently applied to them, as where a child in creeping leans on the arms, or where a nurse frequently lifts a child by one arm (Macewen). The deformities consist mainly of curvatures of the shafts of the bones along with **shifting of the epiphyses** in some cases.

Shifting of the epiphyses is due to the condition of the ossifying cartilage. The extended blue zone at the cartilaginous border, being soft, allows the epiphysis to change its position according to the direction of pressure, and so at the ankle the epiphysis is sometimes displaced inwards, and, as it were, overhangs the joints on its internal aspect. The same may occur at the knee-joint, and the internal condyle may exceed in length the external even after the disease has been cured.

The curvatures of the bones (see Figs. 400 and 401) are due mainly to the weight of the body acting on the softened shafts, and as the pressure acts mainly on the lower limbs the two principal forms are genu valgum and genu varum.

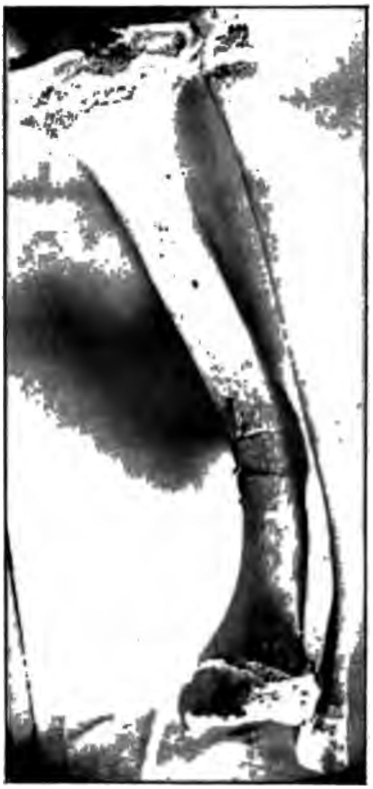


Fig. 401.—Bending of tibia and fibula from rickets. The active disease had ceased in this case.

Genu valgum, or knock-knee, is a condition in which the thigh and leg form an angle at the knee with its apex inwards. This deformity depends usually on several alterations. There is generally a curve of the lower third of the femur, with its convexity inwards, the effect of this being that the internal condyle is lower and the external higher than normal. Along with this there is usually the lengthening of the internal condyle already referred to, and illustrated in Fig. 397, p. 612. As a rule the tibia is not bent, the two conditions named taking the chief part in producing the deformity, but sometimes the shaft of the tibia is at an angle with the epiphysis, as if the latter were to some extent overhanging the former. In addition the femur or tibia sometimes shows an anterior curvature, which of course does not increase the valgum condition.

Genu varum, or bow-legs, is the converse condition to genu valgum. The shafts of the femur and tibia are curved, with the convexity outwards, but these bones take part in the deformity in very different degrees, the tibial curve being more frequent and usually more pronounced than that of the femur.

The long bones being soft and flexible are not so liable as normal bones to complete fractures, but they are specially liable to **Partial fractures or infractions**. If the bone is suddenly bent it does not break across, but is partially torn as when an attempt is made to break a green stick. In this case the concave surface of the bent bone gives way and the convex surface does not. The marrow is torn by the broken concave portion, the broken edges of which may be projected through the marrow to the opposite internal wall. This kind of fracture has been aptly compared by Virchow to the breaking of a quill. These infractions occur most frequently in the lower part of the tibia, also in the pelvis and ribs, and less frequently in the bones of the arm.

Deformities of the chest.—The junction of the cartilaginous and bony ribs is analogous to the ossifying cartilage of a long bone, and undergoes a similar kening in rickets. These parts of the ribs are therefore knobbed, and there hus a row of knobs on each side of the chest—the so-called **Rachitic rosary** . 402). The chest is also liable to deformity from the flexibility of the ribs. ing inspiration the lateral aspects of the ribs are drawn inwards from being ble to withstand the atmospheric pressure, so that instead of the natural arch the convexity outwards, these lateral portions are flattened or even rendered ave. As the ribs take thus a straighter course the sternum is pushed for-

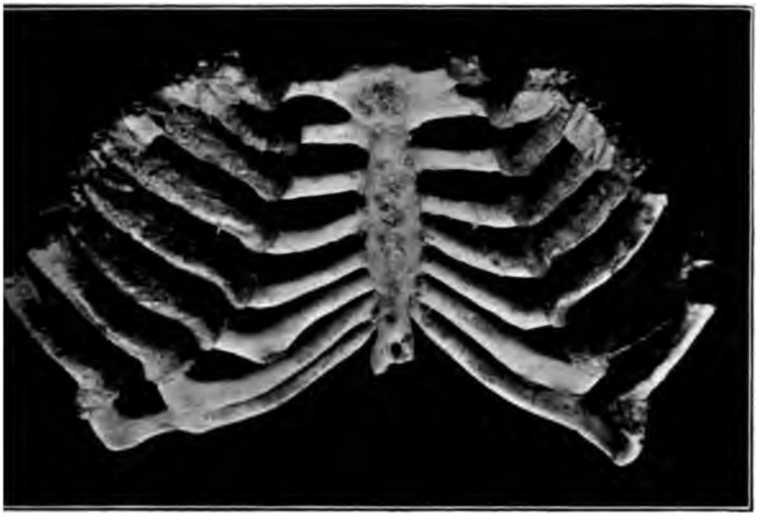


Fig. 402.—The Rachitic rosary. The knob-like swellings at the junction of the cartilaginous and osseous ribs are shown viewed from within.

rd, and the antero-posterior diameter of the chest increased. Fig. 403 repre- ts a section of a rib from a rachitic rosary.

eformities of the vertebræ.—The vertebræ very often escape in the milder ms of rickets, but in many cases they also are composed of abnormally ngy bone, and allow of the occurrence of curvature. Such curvatures are stly exaggerations of the normal antero-posterior curves, but lateral curva- e also occurs. Any considerable curvature may cause narrowing of the chest, d if this be associated with the deformity mentioned above, the interference th the circulation and respiration may be serious.

Deformities of the pelvis.—These are of great importance in the female in lation to the possible occurrence of pregnancy in after life. The chief de- rmity is produced by the weight of the body acting through the vertebral lumn of the sacrum. This bone is pushed forward and the pelvis undergoes corresponding displacement of its parts, the antero-posterior diameter being minished. The growth of the bones here is also stunted, and the pelvis erefore remains unduly small. (See Fig. 404.)

The bones of the head frequently undergo very marked deformities. The bones the face, like the bones generally, are stunted in their growth so that the ce is small. It is also stated that the jaws by the action of the muscles ndergo changes in shape by which the lower jaw is shortened and the upper

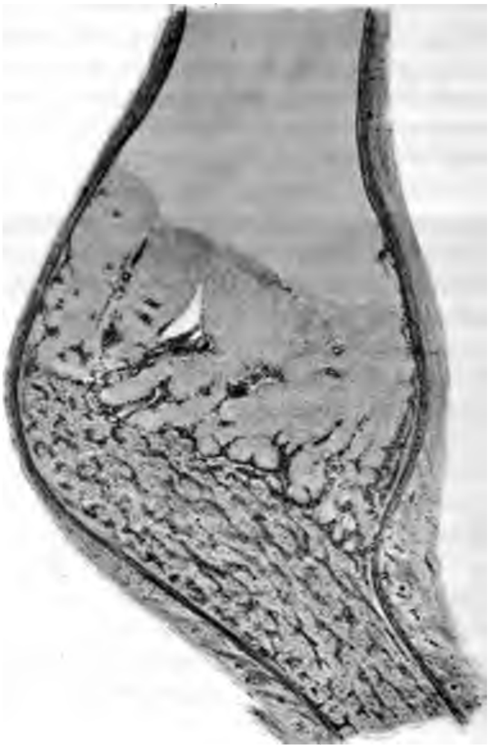


Fig. 403.—Longitudinal section of a rib from a rachitic rosary. × 6.

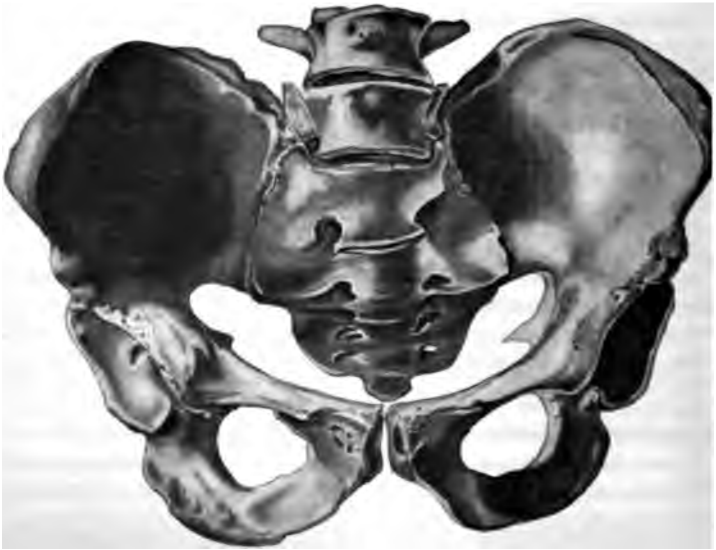


Fig. 404.—The pelvis in rickets. There was great diminution of the antero-posterior diamet[illegible] Caesarian section.

jaw lengthened, so that the teeth of the latter overlap very much those of the former. While these are the conditions in the face the bones in the cranium present striking peculiarities. The flat bones ossify from membrane, and in rickets we have the ossification lingering behind so that at their borders these bones present somewhat broad areas in which there is soft tissue like that under the periosteum. The effect of this is to cause an apparent widening of the sutures and extension of the fontanelles. The closure of the fontanelles is also delayed. The thickness of the skull is increased, just as is that of the shafts of the long bones, the pericranium like the periosteum generally producing a thick layer of loose ill-formed bone. The cranium is thus enlarged in circumference, and at the same time it is commonly flattened on the summit. The enlargement of the cranium, with the stunted condition of the face, causes the well-known overhanging of the brow so often seen.

Another occasional consequence of rickets is the condition designated **Craniotabes.** As we shall see afterwards, this is frequently a consequence of syphilitic disease of the bones, but it occurs also in rickets. The bone in rickets is soft, possessing less power of resistance than normal bone. If the child be lying constantly on one spot, or if the contents of the skull be increased, as in chronic hydrocephalus, then the pressure on the bone may cause it to waste. This occurs most frequently when both these conditions are present, and the bone is as it were between two pressures. In this way may occur thinning and actual perforation of the skull, so that in the midst of the bones there will be holes, where the brain is covered by the soft parts alone. From the nature of the case it will be understood that these apertures are mostly in the occipital or the parietal bone, according as the child lies mostly on its back or side.

Recovery.—This takes place in rickets by the removal of the insanitary conditions, or by the termination of the period of growth. The ossification advances in the cartilage and under the periosteum. The spongy bone produced under the periosteum becomes dense, and so the bone may be unduly heavy and thick, while it is stunted. The deformities having occurred in a rigid structure are rendered even more fixed by the completion of the ossification. There is, however, in the course of time an effort on the part of nature to restore the normal architecture of the bones (see Fig. 397); where they are bent absorption occurs on the convex surfaces and increased new-formation on the concave; there may be considerable restoration of the proper shape in the long bones, but usually much less in the pelvis, head, and thorax.

Deformities of the bones in Cretins.—Although the pathology of Cretinism is not fully elucidated, yet much light has been thrown on it by the discovery of the important lesions following on disease or extirpation of the thyroid gland. The disease is apparently due to a morbid poison which affects primarily the thyroid gland (see under Myxœdema), and the remaining lesions are probably the consequence of the interference with the function of that gland. These lesions concern especially the cutaneous, the nervous, and the osseous systems.

So far as the bones are concerned, the chief lesion is a stunting of them, due principally to defect in the ossification from cartilage. The ossifying margin of the long bones does not, as in rickets, show a proliferation of the cartilage cells, but these, on the contrary, seem to leave off their active function. There is thus a pause or retardation of the process, with the result that the bones, and particularly the long bones, are stunted in their growth. This applies to the basilar parts of the occipital and sphenoid bones which are ossified from cartilage. Here also the elongation of the bone is retarded, with the result that the base of the skull is shortened. The result is similar to that of premature synostosis of these bones (see p. 616), and such a synostosis may itself occur although this is not usual (E. Klebs). Besides the shortening of the base, there is a thickening of the bones of the cranium and sometimes a synostosis of the sutures. As a further indication of retardation, the eruption of the teeth may be delayed and the permanent teeth retained in the jaws.

The Cretin has usually a stunted body with short, thick legs. The head has the face ill-developed and the cranium prominent. The state of idiocy which accompanies these conditions is due more to a direct action on the brain of the causative agent than to the condition of the bones.

Fœtal Rickets. Micromelia Chondromalacica.—These names are applied to cases in which a child is born with a shortened body, short plump limbs, folded skin, prominent abdomen. The bones are short and thick, and present enlargements at their ends. There is thus a certain outward resemblance in the condition of the bones to rickets, but histologically the condition is entirely different. The stunting of the bones is due to an almost entire cessation in the activity of the cartilage, whilst the ossification is not similarly delayed. It is thus almost precisely the converse of the condition in rickets. A synostosis of the base of the skull is apparently a constant concomitant.

The relation of the condition in question to Cretinism has been much discussed. By many it is believed to be a fœtal manifestation of Cretinism, but this is doubted by others (Marchand), especially on the ground that it occurs in regions where Cretinism is not endemic, and also that in such regions Cretinism begins its manifestations after birth. It is to be added that the so-called fœtal rickets has been observed in the calf by Eberth, and regarded by him as a manifestation of Cretinism The exact relation of the two conditions must in the meantime remai in abeyance.

is the name often employed to denote the form

ood.

Literature.—GLISSON, De rachitide, 1650 and 1671; BROMFIELD, Chir. Obs. and Cases, 1757, vol. ii.; STIEBEL, in Virchow's Handb. der spec. Path. u. Therap., Bd. i., 1854; AITKEN, in Reynold's Syst. of Med., i., 1866; SMITH, in Internat. Syst. of Surg., i., 1882; CHEADLE, in Allbutt's System of Medicine, vol. iii., 1897; KASSOWITZ, Die normale Ossification, 1881; POMMER, Osteomalacie und Rachitis, 1885; MACEWEN, Osteotomy, 1880; NEUMANN, Ueber fœtale Rachitis, 1881; EBERTH, Die fœtale Rachitis, 1878; GRAWITZ, Virch. Arch., c., 1885; KLEBS, Allgem. Path., 1889; KIRCHBERG and MARCHAND, Ziegler's Beiträge, v., 1889; SALVETTI, Ziegler's Beiträge, xvi., 1894; SCHMIDT, Lubarsch and Ostertag, Ergebnisse, v., 1900; BARLOW (Scurvy Rickets), Med.-Chir. Trans., 1883, Brit. Med. Journ., ii., 1894; CHEADLE in Allbutt's Syst. of Med., v., 1898.

IV.—RETROGRADE CHANGES.

1. **Atrophy.**—The bones are liable to various forms of atrophy. One of the commonest is that described as **Atrophy from pressure**, which, however, is not true atrophy, but an absorption of bone. It is illustrated by the case of **Aneurysms** which in their growth meet with bony structures such as the vertebræ (see under Aneurysm), or the sternum and ribs. The bone is eroded, while any contiguous cartilage is preserved. In this way, by destruction of the bone, the intervertebral cartilages or the cartilaginous ribs may be rendered unduly prominent. A similar erosion of the bone is sometimes produced in the skull by the **Pacchionian bodies** which may produce deep pouches in the internal table. In a similar manner tumours also lead to destruction of bone.

Senile atrophy of the bones is a true atrophy. It consists in a general diminution in the organic matrix of the bone so that the proportion of lime salts increases, but there is at the same time frequently a diminution in thickness or an increased porosity of the bone. In old age the neck of the femur is frequently shortened and forms a wider angle with the shaft. The calvarium in old people is frequently diminished in thickness and very translucent, but this is by no means constant, nor is it limited to old people.

Atrophy from disuse and from nervous lesions occurs chiefly in cases of paralysis. In pseudo-hypertrophic paralysis, as shown by a specimen in the museum of the Western Infirmary, Glasgow, there is great atrophy of the bones of the lower limb. In infantile paralysis and locomotor ataxia there is also frequently atrophy of the bones at the joints. **After Fractures** which have not united, the bones may atrophy, sometimes from disuse but at other times from interference with the nutrient artery. In cases of atrophy from disuse, from whatever cause, the medullary spaces are enlarged by absorption of the bone. Thus, the shaft is thinned and the spaces in the cancellated tissue are enlarged. The increased bone marrow is a fatty marrow, and the bone as a whole contains more fat than normal—a kind of **Fatty infiltration.**

2. **Osteomalacia or Mollities ossium.**—This condition is liable to be confused with rickets on the one hand and simple atrophy on the other. It differs from rickets in being a disease of mature bone, rarely occurring in children. It leads, like rickets, to weakness of the bones, rendering them liable to various curvatures and deformities.

In its causation the disease is often obscure, but pregnancy seems in many cases the determining cause. It may come on during pregnancy, and run a rapid course. It has also been observed in cases of insanity, and here the softness of the bones may lead to fractures from comparatively slight violence. *Osteomalacia carcinomatosa* is a condition met with occasionally in the late stages of cancer when the bones are secondarily involved.

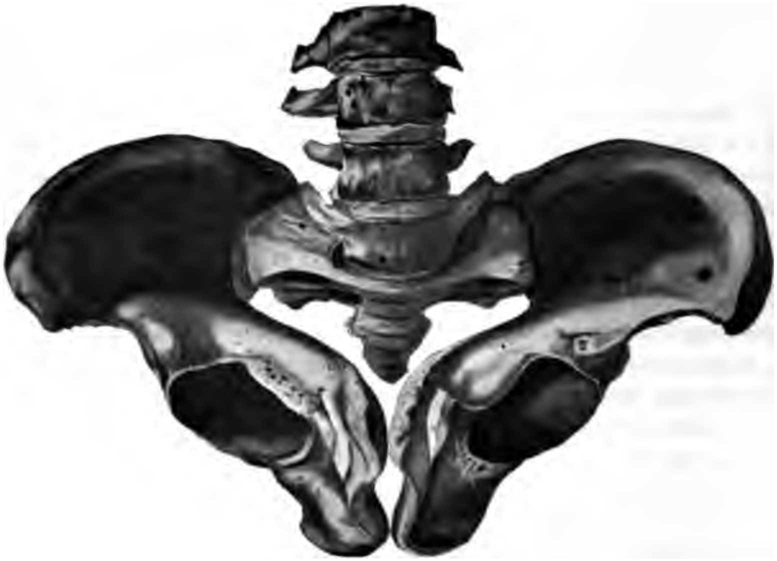


Fig. 405.—The pelvis in osteomalacia.

The disease usually begins in the bones of the pelvis, vertebræ, or ribs, but extends to the rest of the skeleton, continuing to progress up till death. The cases present various curvatures and partial fractures. The pelvis is specially liable to deformity, the acetabula being pushed inwards and the cavity narrowed. (See Fig. 405.) The bones as seen after death are soft and light so that they may float in water, and they are easily cut with the knife or scissors.

The lesion consists of a solution of the bone with a corresponding increase in the medullary spaces. It begins, as shown in Fig. 406, in a decalcification of the bony trabeculæ, in the parts next the medullary spaces and Haversian canals, so that instead of these trabeculæ having in the fresh state a homogeneously opaque appearance, they show at their peripheries a transparent zone in which the bone corpuscles are visible but without their canaliculi. The appearance of these parts is precisely that of bone artificially decalcified by steeping in an acid. The decalcified parts may be rendered prominent by staining with carmine, the unaffected bones remaining uncoloured while the affected parts are stained. The disease advances by the decalcified parts dissolving so that the medullary spaces increase, while the decalcification further encroaches on the bony trabeculæ.

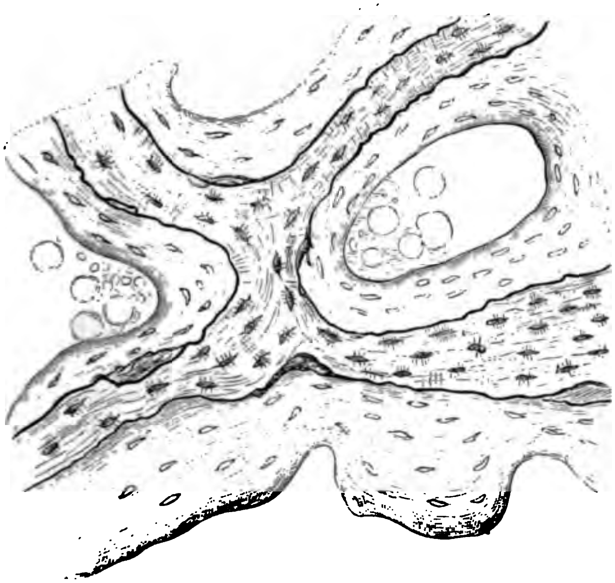


Fig. 406.—A fragment of bone from a case of Osteomalacia. The central part shows the usual appearance of bone, while the marginal parts are transparent, being devoid of lime salts, although still showing bone corpuscles. × 90.

The bone-marrow is in some cases replaced by round-celled tissue as if the process partly partook of an inflammatory character; in other cases the adipose tissue of the marrow seems to undergo increase, so as to fill the enlarged spaces. This appears to have been the case in specimens examined by John Hunter, which he thus describes: "The component parts of the bone were totally altered, the structure being very different from other bones, and wholly composed of a new substance resembling a species of fatty tumour, and giving the appearance of a spongy bone deprived of earth and soaked in soft fat." In these cases the medulla forms a bright yellow, pink, or deep crimson material, and when examined microscopically presents free oil in great quantity with crystals of margarine.

[**Necrosis** is considered in a special section after inflammation.]

Literature.—JOHN HUNTER, quoted by Paget, Lect. on Surg. Path., 1870, p. 108; STANSKY. Rech. sur l'ostéomalacie, 1851; ROKITANSKY, Handb. d. path. Anat.; RINDFLEISCH, Path. Hist.; COHNHEIM, Path. Anat., i.; POMMER, Unters. über Osteomalacie und Rachitis, 1885: VON RECKLINGHAUSEN, Virchow's Festschrift, 1891; REHN (a case in childhood), Jahrb. f. Kinderheilk., xii.; VINCENT, in Internat. Syst. of Surg., 1886; SHATTOCK, Path. Trans., xxxviii., 1887; RIBBERT, Biblioth. Medica., 1893, c., Heft 2; EISENHART (Puerperal osteomalacia), Arbeit. Med.-klin. Inst., Munich, 1893; RITCHIE (Osteomalacia), Edin. Med. Jour., 1896; SCHMIDT, Lubarsch and Ostertag, Ergebnisse, iv., 1899.

V.—INFLAMMATIONS OF BONE, OSTITIS, PERIOSTITIS, OSTEOMYELITIS.

Introductory.—Inflammations of bone are sometimes distinguished according as they affect the periosteum (*Periostitis*), the bone proper (*Ostitis*), or the bone-marrow (*Osteomyelitis*). Such a distinction, however, is not consistent with actual fact. We have already seen that in the growing bone the proper tela ossea is enveloped in an active cellula tissue, which is beneath the periosteum, in the substance of the bon filling its spaces, and in the medulla. In the adult the remains of thi tissue is still present and capable of activity. In inflammations it i this tissue, which by some writers is altogether included as the bon marrow, that is specially affected. The majority of cases of inflammation of bone occur in childhood, when this tissue is still active, an when inflammation occurs in adults the state of activity is restored While this is true it will be understood that the phenomena of inflammation are frequently most manifest on the surface or in the marrow of bones, because the soft tissue is most abundant there. It is also to be remembered that the surface of bones is most exposed to injury, and that inflammations may thus arise which will chiefly affect the periosteum and superficial layers of the bone.

1. **Acute and suppurative inflammations of bone.**—The pyogenic microbes may be directly introduced from without or may reach the bone by the blood, and hence two principal forms may be distinguished.

(*a*) **Acute traumatic ostitis.**—This occurs chiefly in cases of **Compound fracture** where septic processes have occurred in the wound. It used to be very common before the introduction of antiseptic surgery. The suppurative inflammation extends between the broken ends of the ones, and amongst the surrounding soft tissues, and abscesses fre- ently form around the seat of injury. There may also be pus in the edullary cavity, disintegrating the bone-marrow. Extension of the ptic process to the veins is not uncommon, so that **thrombo-phlebitis** d **pyæmia** result.

(*b*) **Acute infective ostitis.**—This condition is described under rious names, such as **Acute periostitis, Malignant osteomyelitis, piphyseal ostitis, Infective ostitis, Pseudo-rheumatic ostitis, Typhus f the limbs.** These names refer to special features presented by ifferent cases. The disease consists in an acute inflammation which early always goes on to suppuration, and occurs without any externally pparent cause.

Causation.—The essential cause here is a pyogenic microbe which in a umber of cases has been identified as the *Staphylococcus pyogenes aureus*. Experiments on animals, already alluded to, show that when a bone is injured and cultures of this microbe are injected into the animal, these will settle in the injured bone and produce a suppurative inflammation. In man the bone is always so far predisposed in respect that the disease is one of **Adolescents** in whom the tissues are excessively active, and there is usually also the history of an injury inflicted before the beginning of the illness. The bones most frequently affected are those most exposed to injury. The fact that boys are much more frequently attacked than girls, points in the same direction. It may, erhaps, be said that when, by accident, the microbes in question are resent in the blood, perhaps by absorption from the alimentary canal, n injury, otherwise trivial, may determine their settlement in a bone, nd so the disease may be induced.

Character of lesions.—The inflammatory process presents varying egrees of severity and extent, as well as considerable variety in its at. The bones most frequently affected are the long bones, more pecially the tibia, but it occurs in the pelvic bones, the vertebræ, pecially the atlas, and in other situations.

In some cases the periosteum is chiefly affected, and to these the ame of **Acute periostitis** is often given. The periosteum is swollen nd hyperæmic, and suppuration usually ensues rapidly. The pus ccumulates between the periosteum and the bone, and the periosteum is sometimes gangrenous. The bone beneath frequently undergoes necrosis, but this result is by no means constant.

In other cases there is a more diffused inflammation, affecting the bone and medulla as well as the periosteum, or there may even be a special involvement of the medulla. In these cases pus is present in the medullary cavity and in the substance of the bone. According to

Ollier the inflammation frequently localizes itself in the neighbourhood of the ossifying borders of the shafts of long bones. This region as it is next the epiphysis (though a portion of the diaphysis) he designates **juxta-epiphyseal.** The reason of this localization will be apparent from the fact that this is the region of greatest ossific activity.

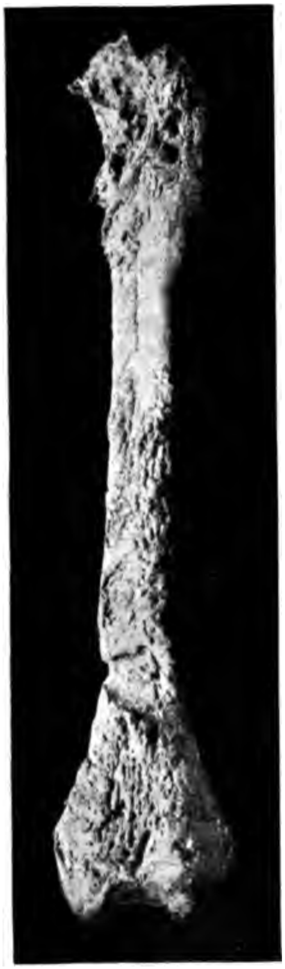


Fig. 407. New-formation of bone in a case of necrosis of the femur.

Along with these local phenomena there is commonly more or less fever, and this may be very great in comparison with the local phenomena. The designation 'typhus of the limbs,' points to the occurrence of such severe febrile phenomena.

Necrosis may occur in the several forms of this disease, but it is by no means uniformly present, its occurrence depending chiefly on local interference with the blood-supply, and perhaps also on the condition of the person affected. (See under Necrosis.)

Pyæmia occasionally develops as a result of the extension of the septic process to the veins.

(*c*) **Post-febrile ostitis.**—An acute ostitis, in many respects similar to that just described, sometimes follows acute febrile conditions, such as acute rheumatism, typhoid fever, scarlet fever, measles, dysentery, etc.

(*d*) **Abscess in bone.**—Abscesses are met with in the cancellous tissue of the ends of the long bones, where they are probably the result of an infective or post-febrile ostitis. The abscess expands the end of the bone, which may attain large dimensions.

2. **Chronic inflammations of bone. Chronic ostitis.**—In its **Causation**, chronic ostitis is very varied. All sorts of irritants acting on the bones lead to it. Traumatic agents causing wounds, and more especially fractures, are a frequent cause. The processes concerned in the healing of fractures are essentially those of chronic inflammation. Necrosis, from whatever cause, leads to a

ronic ostitis around the dead piece (see Fig. 407). Again, inflam-
tions of joints, whether tubercular, traumatic, rheumatic, or other,
d to inflammations of the neighbouring parts of the bones, the
ent which causes the inflammation in the joint acting also by
sorption and in a diluted form on the bone. Syphilis and tuber-
losis, although producing specific lesions, also lead to ostitis.
osphorus produces a peculiar form of ostitis associated with necrosis.
ee under Necrosis.)

The chronic inflammation produces activity in the soft structures of
e bones, with the consequence that as regards the bony tissue itself
o opposite conditions, namely, rarefaction and new-formation of the
one are, according to circumstances, produced. It is customary to
peak in this sense of a **rarefying** and a **formative ostitis**, but these
erms in reality refer to local processes and simply indicate the local
esults of the inflammation. It is quite common in the same case to
ave, in different regions, both a rarefying and a formative ostitis. The
oft structures of the bone, the relation of which to ossification has been
referred to in the introductory section, become cellular under the
influence of the inflammation, and are thus converted into **Granulation**
issue. This occupies the various situations already referred to as those
ccupied by the active tissue of growing bones. It is present in the
edullary spaces, in the Haversian canals, and on the surface of the
one beneath the periosteum. It is an active tissue and produces
hanges analogous to those of the similar tissue in growing bones.
hese changes consist in absorption of the existing bone on the one
and and new-formation of bone on the other.

The **Rarefaction** of bone (**rarefying ostitis**) occurs by enlargement
f the spaces and channels, such as the Haversian canals and
edullary spaces. It is manifested chiefly in the shafts of long
ones, where the dense bone may be converted into a loose cancellous
ssue. There is usually at the same time new-formation of bone, so
at the thickness of the shaft is increased. The granulation tissue
cting on the bony trabeculæ causes absorption of the bone, and it is
elieved that the giant-cells or myeloplaques are chiefly engaged in the
rocess.

New-formation is a more constant and important effect. In all
rms of inflammation there is liable to be thickening of the bones
om new-formation on the surface. As this takes place under the
eriosteum it is generally ascribed to periostitis, and this membrane
s generally credited with a special power of bone-formation. It is,
owever, merely the local circumstances which determine the situation
f the new-formation, and there is not infrequently an encroachment

on the medullary cavity as well as apposition on the surface. The new-formed bone has a rough tuberculated surface as shown in Fig. 408, p. 637. The new-formation may follow on the process of rarefaction so that a dense thickened bone may result (*condensing ostitis*).

The process of new-formation is similar to that in ordinary ossification. The granulation tissue cells act as osteoblasts, surround themselves with osseous matrix, and remain buried in this as the bone-corpuscles.

Literature.—STANLEY, On diseases of bones, 1849; KLEBS, Beitr. zur path. Anat. der Schusswunden, 1872; ROSENBACH, Mikroorganismen b. d. Wundinfectionskr., 1884; GARRE, Fortschritte der Med., 1885; OLLIER, in Internat. Encycl. of Surg., vi., 1886; LANNELONGUE et ACHARD, Annales de l'Inst. Pasteur, v., 1891; JORDAN, Beitr. z. klin. Chir., x., 587; KOPLIK and VAN ARSDALE, Amer. Journ. Med. Sciences, ciii., 1892; PARK, Medical Record, 1895.

VI.—HYPERTROPHY OF BONE. HYPEROSTOSIS, PERIOSTOSIS.

The distinction between hypertrophy of bone and chronic inflammation is sometimes a difficult one to draw. In the former there is a new-formation, as in the latter, and it may be only the absence of a definite inflammatory irritant which may determine the distinction. In true hypertrophy new bone is formed of a strictly normal character, and the result is a general or local enlargement of the bone. A general enlargement of a bone is called **Hyperostosis**, while a partial enlargement is **Periostosis**.

The **Causation** is in many cases obscure. It may be produced, as already mentioned (Fig. 103, p. 261), by a prolonged hyperæmia, which gives rise to increased nutritive activity. In other cases it is **Compensatory**, as where the fibula undergoes hypertrophy in consequence of an ununited fracture of the tibia. In other cases we have to do with a gradual enlargement of unknown cause.

A **General hyperostosis**, in which the bones generally are enlarged, has been described by Paget under the designation **Osteitis deformans**. As the name implies, Paget regarded the condition as the result of inflammation. The disease usually affects in the first place the bones of the lower limb and the cranium. These undergo great enlargement, while at the same time their tissue is opened out as by a rarefying ostitis. The enlarged medullary spaces are filled as in inflammation with a tissue which is abundantly cellular. The bones are also softened, so that various curvatures are produced. The name **Osteoporosis** is sometimes given to it.

A peculiar feature in this disease is the frequent co-existence of tumours, which may be either sarcomatous, cancerous, or lymphatic (as in a case of Goodhart's), but are not always seated in the bones. A hyperostosis affecting single bones has been observed chiefly in the skull and face. These bones may be enormously enlarged, and the face in particular may take on characters which have suggested Virchow's name of *Leontiasis ossea.*

Periostosis is more unusual apart from inflammatory enlargement, but partial enlargements of the processes of bones occur.

Hypertrophic Pulmonary Osteo-arthropathy.—This peculiar affection, the pathology of which is still obscure, has been confounded with acromegaly chiefly for the reason that in both affections there is great enlargement of the hands and feet (see Acromegaly, p. 239). In hypertrophic pulmonary osteo-arthropathy the enlargements present special features. The terminal phalanges are club-shaped, the nails are curved like a parrot's beak, and the bones of the forearms and legs often show a striking increase in size. In this affection again, the skull and face, including the soft parts, are practically normal and there is no obvious change in the pituitary body. The joints are not infrequently affected. There is effusion and erosion of cartilage, and in the bones evidences of periostitis, with new-formation of osseous tissue, and sometimes of osteomyelitis.

In almost every recorded case chronic pulmonary or cardiac disease has been present. The osteo-articular changes are usually regarded as secondary to these. It is possible, as Marie suggests, that there is absorption of some toxic substance from the pulmonary lesions, and that this substance has a special affinity for certain osseous and articular structures.

Literature.—PAGET, Med. Chir. Trans., vol. lx., 1876; TREVES, Path. Trans., xxxii., 1881; SILCOCK, ibid., xxxvi., 1885; ROBINSON, ibid., xxxviii., 1887; GOODHART, ibid., xxxix., 1888; CLUTTON, ibid.; HUTCHINSON, PAGET, and others, Illust. Med. News, vol. ii., 1889, pp. 169-189; GILLES DE LA TOURETTE et MARINESCO, Nouv. Iconograph. d. l. Salpêtrière, 1895; BAMBERGER, Zeitschrft. f. klin. Med., xviii., 1890; MARIE, Revue de Méd., x., 1890.

VII.—NECROSIS OF BONE.

Death of bone is of frequent occurrence, and it leads to such obvious phenomena that the term necrosis has been almost monopolized by surgeons for this condition.

Causation.—Necrosis in bone is nearly always the result of interruption of the blood-supply. From its frequency it might be supposed that bone readily succumbed to such deprivation, but the reverse of this seems to be the case. Macewen's observations in regard to transplantation seem to show this. (See under Transplantation.) Bone receives its supply of blood partly through small vessels which pass from the periosteum and partly by larger vessels, of which there is generally a special one for each bone, which penetrate the bone and are distributed from within, such vessels being specially named the nutrient vessels.

Necrosis is mostly brought about by the periosteum being raised, sometimes traumatically, but generally as a consequence of inflammation, especially when pus accumulates between the membrane and the bone. The irritant producing the inflammation will in many cases have its share in causing the necrosis. By the raising of the periosteum the periosteal blood supply is cut off, and the nutrient vessels may also be severed. According to Macewen the supply of the nutrient vessel of a long bone is generally sufficient to keep the bone alive even when the whole periosteum is stripped. This author records a case in which the whole diaphysis of the tibia was denuded of periosteum, but in which the persistence of the nutrient vessels caused all the bone to survive except a small superficial scale.

Necrosis is an occasional result of inflammation in the bone itself, and it occurs in the form of caseous necrosis in tuberculosis. Injuries, by separating a portion of bone, will sometimes produce necrosis, and will do so almost inevitably if septic processes coincide.

Resulting conditions.—The dead piece of bone is in itself inert, and undergoes merely passive changes. It retains its form and general appearance, but if it remain long, being macerated by the juices of the body, it assumes the characters of macerated bone. It then appears white and dry, and, as it contains little organic matter, it feels hard to the probe and gives a sound on being struck.

Inflammation is a constant concomitant of necrosis. If the latter has not been due to inflammation, then it leads to it secondarily. The dead piece of bone seems to stimulate the surrounding living tissue, and to lead to a chronic inflammation. By means of a rarefying ostitis the Haversian canals and medullary spaces enlarge and the bone immediately around the dead piece being replaced by granulation tissue, the necrosed piece becomes a **Sequestrum.**

At the same time new-formation commonly occurs, chiefly in the subperiosteal tissue, which has probably been separated from the dead bone, but also in the medulla. There is thus produced an irregular layer of new bone, as shown in Figs. 407 and 408. This new bone is largely subperiosteal, and in many cases it forms an external shell which may exercise the function of support instead of the bone which has died. This external shell frequently confines the dead piece, · of access for removal by the surgeon. It is enerally provided with apertures called Cloacæ through which he pus of the original suppuration has passed, and which have emained as canals or gaps in the new-formed shell.

The ultimate disposal of the dead bone occurs in different ways according to circumstances.

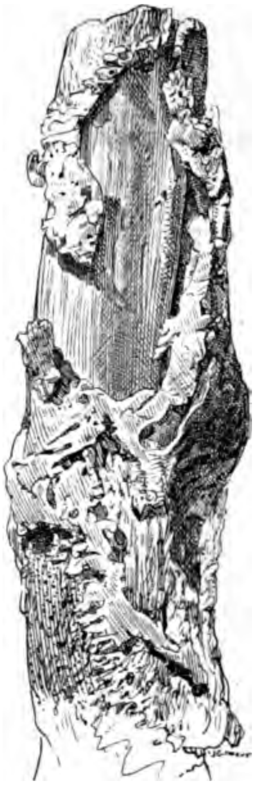


Fig. 408.—Necrosis of femur. The smooth necrosed piece is seen with irregular new-formed bone around.

Absorption of dead bone is of frequent occurrence. In simple fractures it is probable that detached pieces of bone frequently die and become absorbed. Similarly in compound fractures pieces are not infrequently visible in the wound, having the dead white colour and hard feeling of sequestra, but if the wound remains aseptic they are absorbed. Again, at the ends of stumps sequestra often form, and they are sometimes, at least partially, absorbed. In all these cases, and even in acute infective ostitis, the dead bone may be absorbed if septic changes be averted or overcome.

The absorption is effected by the **Osteoclasts.** In Figs. 409 and 410 the appearances are shown as observed by the author in a case of limited necrosis at the end of a stump, in which absorption was in progress. Here the Haversian canals and medullary spaces as seen in Fig. 409 are enlarged, and their borders have a worm-eaten appearance. This latter is shown in Fig. 410 to be due to the existence of Howship's lacunæ, in which are giant-cells exercising their function of osteoclasts. Sometimes a regular row of such cells was visible, as if feeding on the bone, and they were occasionally almost buried in flask-shaped spaces (as at the left in Fig. 410). By this process bone may be entirely absorbed.

A similar process of absorption occurs, not only in pieces of bone which have died in the body, but in pieces of ivory or bone which have been introduced for therapeutic purposes, such as ivory pegs used in cases of ununited fracture, bone drainage tubes, etc.

Absorption does not occur where the dead bone, having become septic, is itself a source of serious irritation. Thus a piece of dead bone may lie for years in a suppurating cavity almost unchanged.

Cornil and Ranvier, for example, figure a transverse section of a sequestrum of the femur which had remained thirty years bathed in pus. In this time it had undergone no corrosion and had all the characters of macerated bone. The position of the sequestrum inside the shell of new bone often causes its retention, and its removal is only effected by partial destruction of the external shell.

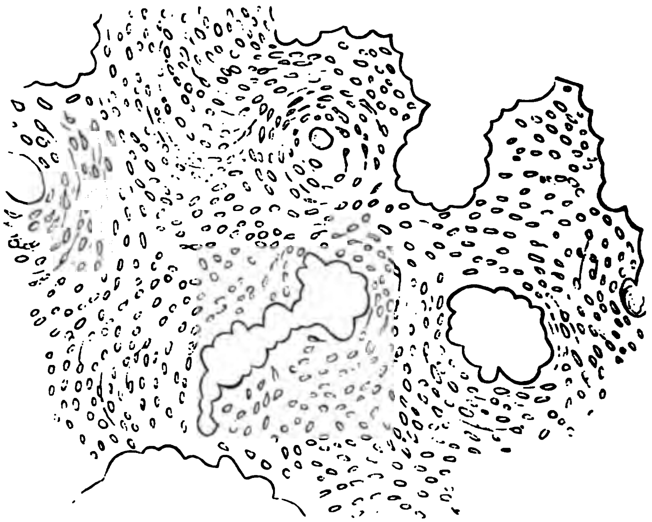


Fig. 409.—Section of a piece of necrosed bone which had been undergoing absorption. The margins of the bone at the medullary spaces and Haversian canals have an eaten-out appearance from the presence of Howship's lacunæ. × 80.

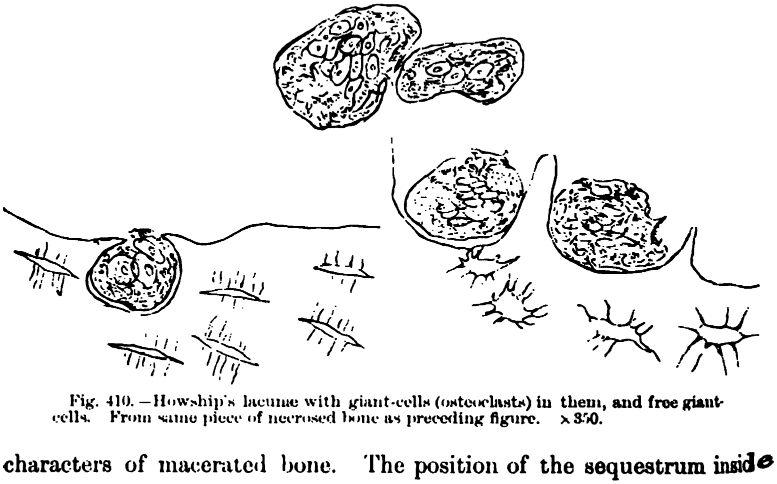


Fig. 410.—Howship's lacunæ with giant-cells (osteoclasts) in them, and free giant-cells. From same piece of necrosed bone as preceding figure. × 350.

Phosphorus-necrosis.—This condition occurs chiefly in persons who are employed in workshops where lucifer matches are manufactured, who are thus exposed to the vapour of phosphorus. The vapour locally, on the jaws chiefly, and it is said that persons with carious ı are particularly liable to be affected. The phosphorus produces nflammation mainly of the periosteum, resulting in a great new- ıation of cancellated bone on the surface of the jaw. This bone afterwards become condensed by the ossification encroaching on medullary spaces. After a time the inflammation leads to suppura- , the pus forming between the new-formed bone and the original e of the jaw. From this results a necrosis of the jaw which may olve the entire bone, and may extend to the new-formed bone. The ılting suppurations are usually fatal, but after removal of the uestrum healing may occur. Microbes of various kinds are present the pus. In the discharge from six cases examined by Stockman tubercle bacillus was found.

'rom the observations of Wegner it appears that phosphorus acts as a general nulant to the structures concerned in the formation of bone. The phosphorus our acting directly stimulates so violently as to produce the inflammation and rosis just described, and this result has been produced also in rabbits exposed the vapour of phosphorus. When given in small doses internally, phosphorus duces in growing animals a distinct stimulation of the process of formation of ie. In such cases the bone produced at the ossifying border of the cartilage is a spongy bone but a dense layer, and there is also an unusually dense bone duced beneath the periosteum. It is noteworthy that in growing animals to om small doses of phosphorus were given, while insufficient quantities of lime re supplied, there was a great production of osteoid tissue, somewhat like that duced in rickets.

iterature.—Macewen, Annals of Surgery, 1887; Wegner, Virchow's Arch., lvi., 2; Coats, Glasg. Med. Jour., vi., 1874; Bibra und Geist, Krankh. d. Arbeiter in Phosphorfabriken, 1847; Trélat, De la nécrose causée par le phosphore, 1857; irsch, Arch. d. Heilk., 1868; Cameron, Glasg. Med. Jour., xvi., 112, 1881; eckel, Langenbeck's Arch., xxxix., 1890; Jost, Brun's Beiträge, xii., 1894; ockman, Brit. Med. Jour., i., 1899.

III.—REGENERATIVE PROCESSES. HEALING OF FRACTURES. TRANSPLANTATION.

In the various regenerative processes the structures already referred as having to do with the growth of bone are concerned. The struc- res become cellular, their existing cells multiplying by karyomitosis, d they thus renew their powers of new-formation. The processes ncerned are really those of chronic inflammation.

1. **The Healing of fractures.**—In the case of simple fractures or of ose which are protected from septic contamination, the process of aling generally begins soon after the infliction of the injury.

According to Ogston, in compound fractures and dislocations, the forcible dispersion of fluids by the agent producing the injury, as well as the dragging on tissues of varing degrees of distensibility, often leads to the formation of extensive spaces or cavities beneath the skin, amongst the muscles and elsewhere. As these may be the seat of septic processes they require careful attention.

The actual injury induces an acute inflammation. There is hyperæmia, serous exudation and exudation of leucocytes, and also a certain amount of hæmorrhage. These inflammatory manifestations are present in the torn periosteum and in the medulla. The acute inflammation, however, usually subsides in a few days; its prolongation, as in septic cases, is inimical to healing. Any considerable accumulation of blood is also inimical to healing, but as a general rule the effused blood, having been transuded into the tissues around, passes into the lymphatics, or, if it remain more permanently, it is disposed of by being eaten into by the new-formed inflammatory tissue.

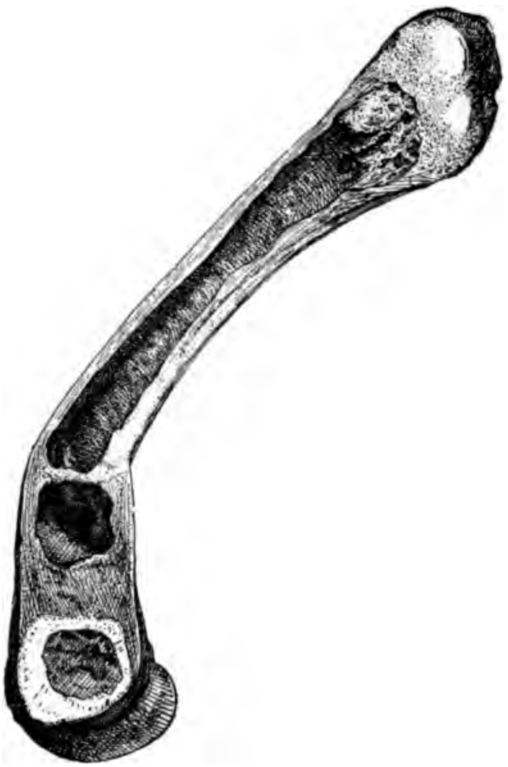


Fig. 411.- Green-stick fracture of femur of infant. The septum or internal callus consists of bone and cartilage posteriorly, and of fibrous tissue anteriorly.

On the subsidence of the acute inflammation the soft structures show active changes. By a process of karyomitosis (as observed by Krafft) the subperiosteal and medullary cells proliferate, so as to form granulation tissue. A similar process is visible in the endothelium of the vessels, by which means new vessels are formed. The tissue of the bone itself partakes in the process, so that it is opened out by a rarefying ostitis. We have thus a vascular granulation tissue formed in these three situations, but its amount varies greatly according to circumstances.

From this tissue the **Callus** is formed. This name is given to the ew-formed tissue which in the first instance unites the broken ends of e bones. It may be of considerable bulk as shown in Fig. 412, so as o form a kind of case for the fractured ends; it may be very scanty in mount as in the case of incomplete or "green-stick" fractures (Fig. 411). he callus, as shown in Figs. 413 and 414, consists under varying ircumstances of **Different forms of connective tissue.** The formative ells produced in the way mentioned above have the characters variously f osteoblasts, fibroblasts, or chrondroblasts, and may develop bone (*c*, *c*, *c* in Fig. 413), cartilage (*b*, *b*, *b*), or connective tissue (*d*, *d*, *d*). The form of tissue thus produced seems to depend on the condition of the parts as to movement. In parts where there is little movement bone will form, where there is much movement fibrous tissue, while cartilage takes an intermediate position. From this it arises that in man, where the bones re usually kept rigid by splints, the callus is formed chiefly of bone, hereas in animals it is largely formed of cartilage and fibrous tissue. ut in man, where circumstances do not allow of the parts being kept t rest, then we have cartilage and fibrous tissue along with bone. This as the case in the specimen from which Figs. 412 and 413 were taken. number of fractures had occurred in the ribs in an insane person, and ey were only discovered after death.

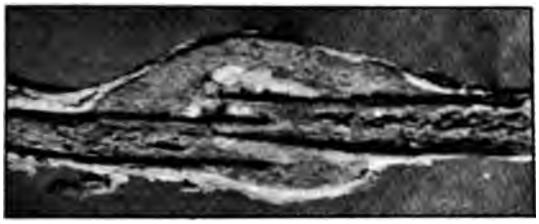


Fig. 412.—Fracture of rib with callus, seen in section. The broken ends are shown overlapping each other. These are enclosed in a sheet of callus. Natural size.

It not infrequently happens that a **Piece of bone is detached** and olated. This, however, does not interfere with the process of healing. small, the piece of bone will survive, and having acquired vascular hesions, will undergo a rarefying ostitis and assist in the production callus. If large, or if unfavourably situated it may die, and in that se it undergoes absorption by the granulation tissue (see under ecrosis). In compound fractures it is not uncommon to see a piece of ead bone eaten into and penetrated by granulations.

The callus produced as above is generally described as **Provisional allus**, because much of it is removed before complete restoration.

Names are also given according to the position of the callus. **External callus** is formed at the surface from the subperiosteal layer, **Internal callus** is formed from the bone-marrow and endosteum (Fig. 413), while

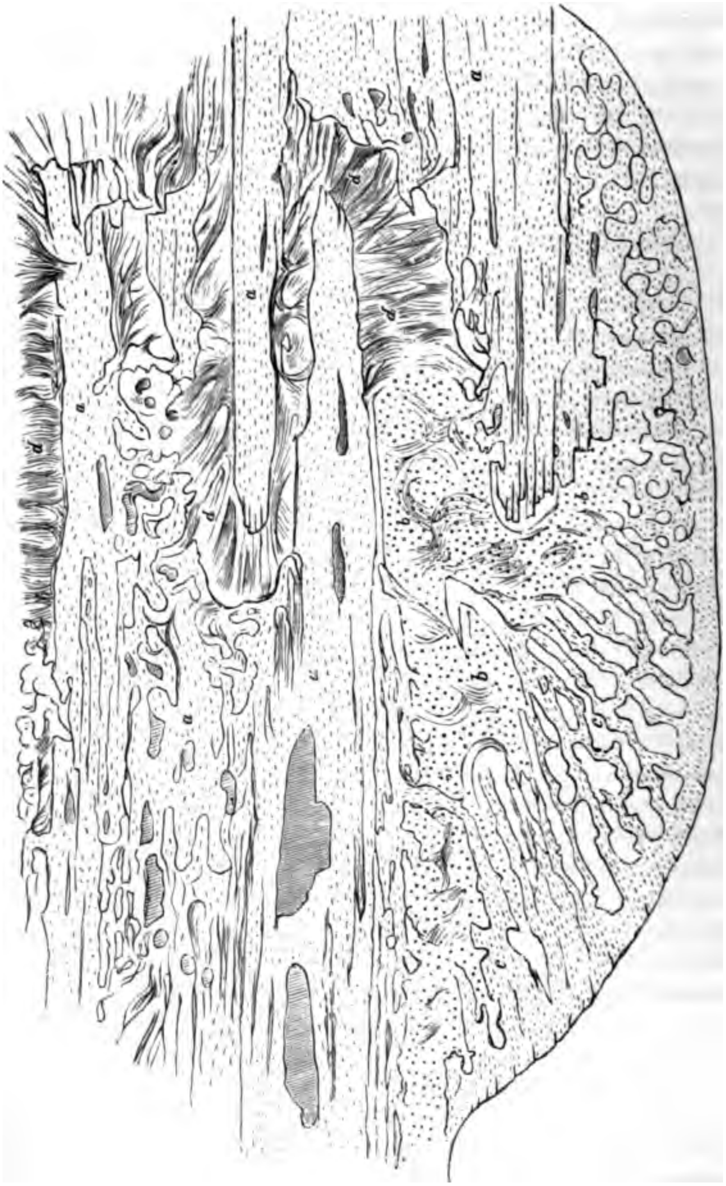


Fig. 413.—Longitudinal section of a fractured rib, showing callus, etc.; the section is imperfect at the upper part. *a, a, a, a, a*, the broken extremities of the rib dove-tailing into each other; *b, b, b*, new-formed cartilage constituting part of the callus; *c, c, c*, new-formed bone constituting the external layers of the callus; *d, d, d, d*, new-formed connective tissue constituting the more immediate bond of union between the broken ends. ×11.

termediary callus is between the ends of the bones and produced, some extent at least, from the bone itself.

When the bones are fully united any excess of callus is disposed of, d little is left but what is necessary to fill up the space between the

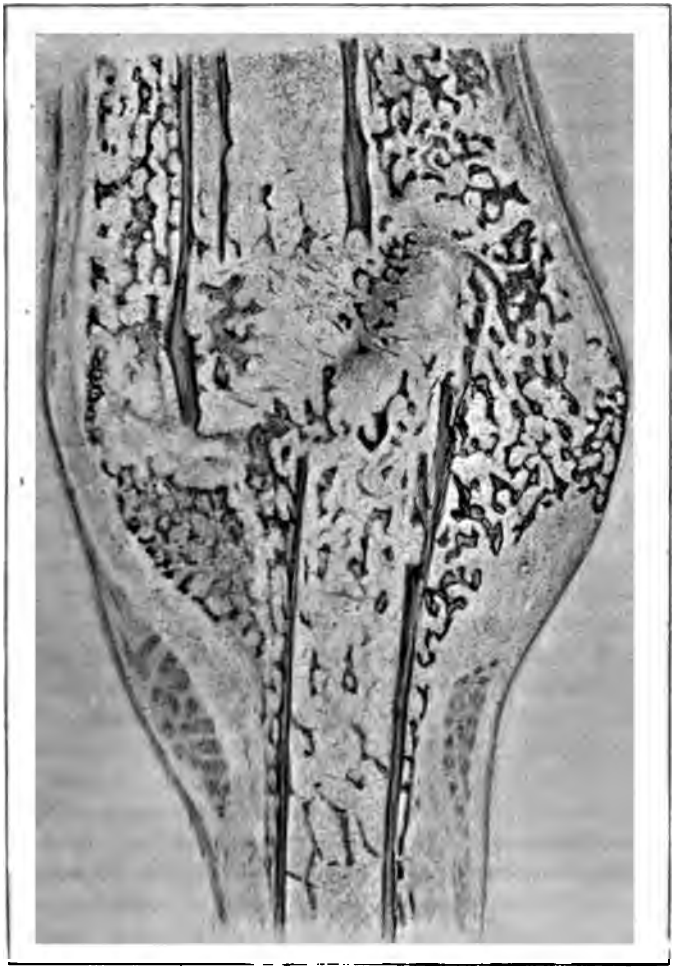


Fig. 414.—Fracture of ribs with callus seen in section. × 10.

fragments as seen in Fig. 415. There also occurs a process of moulding by which the architecture is restored according to the principles already mentioned. When the bone comes again into active use there is an absorption and new-formation so as to enable the bone to resist the pressure and traction to which it is liable. Where th bones are united considerably out of position as in Figs. 416, 417, th internal architecture is greatly modified. When a series of bone such as the ribs, are simultaneously fractured union by bone no infrequently occurs between the adjacent bones (see Fig. 418).

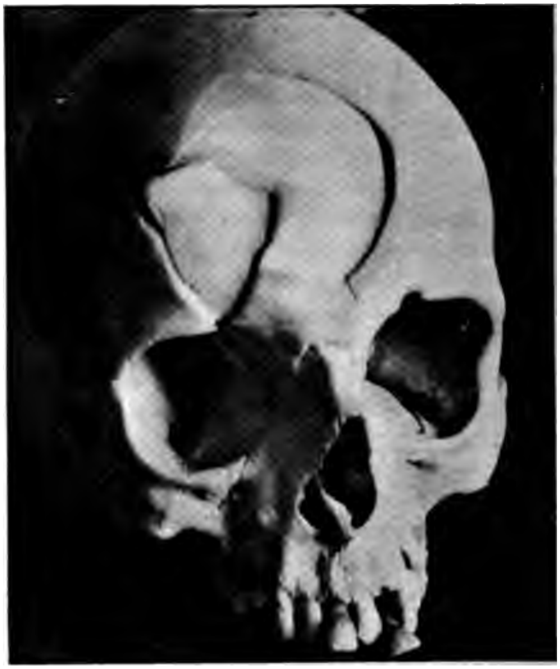
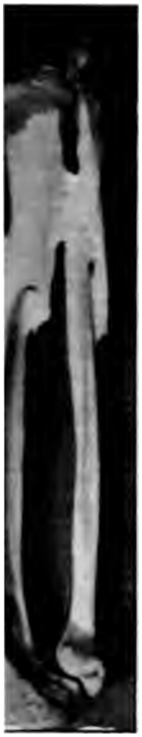


Fig. 415.—Healed fracture of skull. A severe injury was inflicted years before. The parts had become completely consolidated and the edges rounded, but with the displacements shown.

From what has gone before it appears that the amount of actu bone entering into the callus varies greatly, and there may be mor fibrous tissue ultimately than bone. This occurs especially whe the parts are not kept at rest. On the other hand the whole proce may be a very inactive one and from tearing of vessels or otherwi the blood-supply may be deficient. In such ways as these ari **Ununited fractures**, in which the bones are connected with fibro tissue (Figs. 417 and 419). In some cases there is even a kind of **Fal joint** or **Pseudarthrosis** formed, with smooth articulating surfaces a an approach to a synovial cavity.

2. **Transplantation of bone.**—It has usually been stated that, wh pieces of the periosteum are transplanted, they proceed to the form

bone. This is only true in regard to the deep layer of the um, or more properly the subperiosteal layer. The periosteum consisting of fibrous tissue, is incapable of producing bone. On er hand the bone itself, or the tissue in its various cavities,



16.—United Frac-
tibia and fibula
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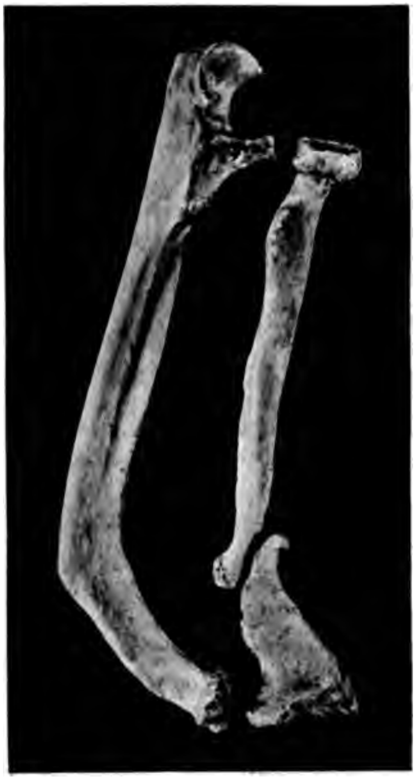

Fig. 417.—Fracture of both bones of the forearm. The ulna is firmly united and there is considerable displacement. The fracture of the radius had been ununited for years.

as the endosteum, is capable, as we have seen, of forming Hence a transplantation of periosteum, including the sub- al layer, or of pieces of bone, may be followed, not only by of the pieces, but by new-formation of bone from them.

plantation of the periosteum is not an uncommon patho- process. The periosteum may be raised by the accumulation eneath it, or it may be stripped off by an injury, and in that the ossifying layer be preserved, ossification occurs. This fact is sometimes taken advantage of by surgeons, who detach the periosteum, and displace it with a view to the ultimate formation of bone.

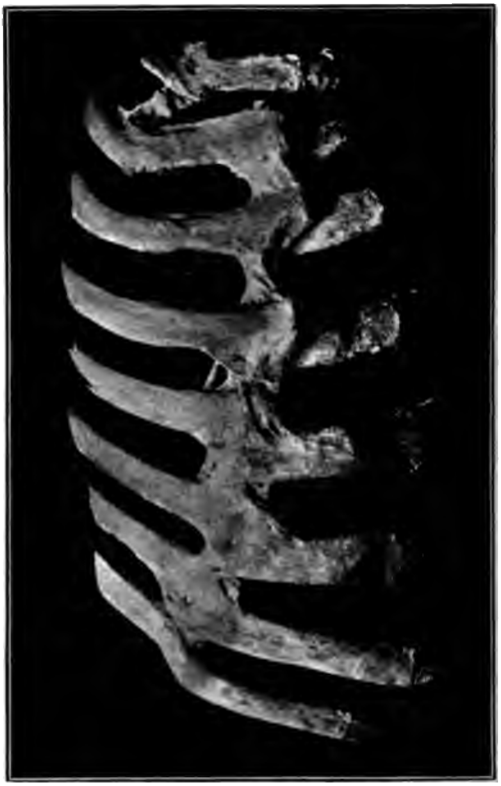

Fig. 418.—Fracture of the eight upper ribs with firm osseous union.

The Transplantation of bone itself has been demonstrated chiefly by Macewen. It is apparent from his observations that bone, contrary to what might be expected, has great power of retaining its vitality when detached from its connections. A piece of bone transplanted will, even when of considerable size, survive long enough to acquire fresh vascular connections, and, in accordance with what occurs in transplanted structures generally, it will often proceed to grow in its new position. Accidental transplantation must often occur in connection with fractures, and the detached piece of bone, as mentioned above, usually survives.

Advantage has been taken of these facts in an ingenious way by Macewen. In the operation of trephining, a circular piece of bone, often of considerable size, is ved from the skull. This piece of bone may be preserved during the ation on the brain and re-implanted in the gap, at the close of the operation. ptic contamination is prevented, the bone survives and grows into its place, g up by new-formed tissue the interval made by the saw.

ill more interesting are the results of transplantation in the treatment of a case hich the shaft of the humerus had been lost by necrosis. In this case pieces

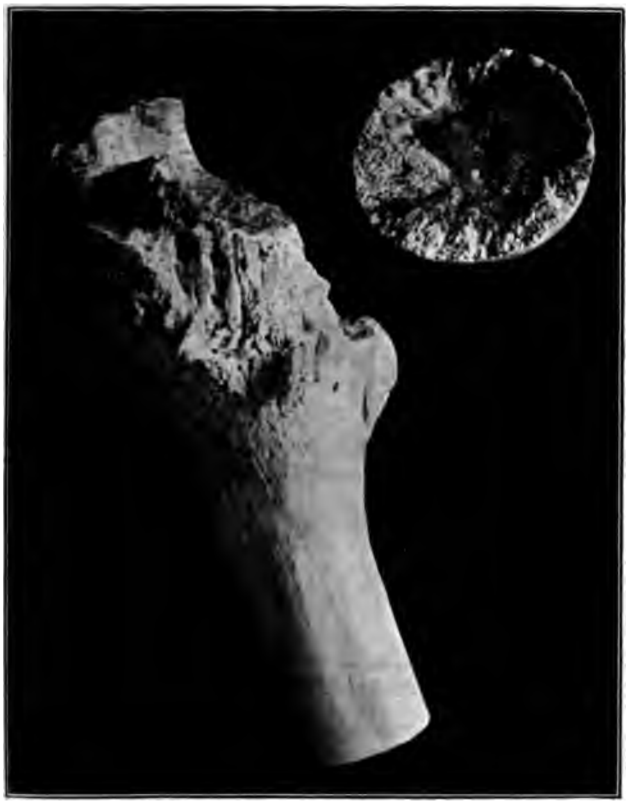

Fig. 419.—Old intra-capsular fracture of femur.

one removed from the femurs of other patients (in the operation of Osteotomy) e broken up into small pieces and inserted among the muscles into a sulcus ere the shaft of the bone should have been. By three operations the bone was tored to the extent of four and a quarter inches, and there was a subsequent wth in the course of seven years of an inch and three-quarters. This case nonstrates that pieces of the bone removed from one person to another not only vive but grow in their new position. Transplantation from one of the lower mals does not succeed, the foreign bone acting as an irritant.

iterature.—Malgaigne, Traité des fract. et luxat., 1855; Gurlt, Handb. d. Lehre d. Knochenbrüchen, 1862; Krafft, in Ziegler und Nauwerk's Beiträge, 1884;

OLLIER, Traité de la régénération des os, 1867; MACEWEN, Phil. Trans. of Roy. Soc., 1881, and Annals of Surg., 1887; MACGREGOR, Jour. of Anat. and Phys., xxvi., 220; OGSTON, Med. Chronicle, Nov., 1888; MARCHAND, Der Process d. Wundheilung, 1901.

IX.—SPECIFIC NEW-FORMATIONS. TUBERCULOSIS, SYPHILIS, ACTINOMYCOSIS.

1. **Tuberculosis of bone.**—This is an exceedingly frequent affection, and one attended usually by very serious results. The lesions to be here described are not universally recognized as tubercular in character, although, as observation widens, the dissentients from this view diminish. The term **Scrofulous** is here, as in other structures, equivalent to tubercular. **Caries** is another term which, as will be explained below, is nearly equivalent to certain forms of tuberculosis.

Causation.—The tubercle bacillus in most cases reaches the bones by the blood. In a large proportion of cases both joints and bones are affected, and it is not determined to what extent the one or the other is the primary seat. It is demonstrable that primary disease of the bones frequently extends to the joints, and it may afterwards attack other bones entering into the articulation. On the other hand when primarily affecting the joint it may extend to the bones concerned in the joint. It is probable, however, that in the great majority of cases the bones are primarily affected, although the lesion in the bone may be so small, and the parts so altered by subsequent changes, that it may be difficult to demonstrate the exact commencement.

The tuberculosis begins in the spongy parts of the bones. It is very common in bones which are largely composed of spongy tissue, as the vertebræ and the bones of the hands and feet, while in the long bones it affects chiefly the articular extremities. In the case of the vertebræ, it mostly affects simultaneously the proximate surfaces of two bodies (see Fig. 420), as if it took origin in the intervertebral cartilage. In this respect the author's observations correspond with those of Wilks and Moxon.

While spongy bone evidently forms a favourable nidus for the tubercle bacillus, there are two further predisposing elements frequently traceable. Tuberculosis is most frequent in young persons, the actively growing bone apparently predisposing to it. This applies especially to the bones of the extremities, and to a less degree to the vertebræ. Injury is the other predisponent. This is a fact of clinical observation which has been confirmed by the experiments of Schüller, who found that after injecting tubercle bacilli into the blood, he could induce tuberculosis of the joints by inflicting injuries such as would otherwise be readily recovered from.

Characters of the lesion.—The tuberculosis affects primarily the soft tissue or medulla contained in the meshes of the cancellated tissue, and secondarily the bony trabeculæ. The spaces become occupied by round-celled or granulation tissue, in which tubercles of typical structure are visible. The granulation tissue eats into the bony trabeculæ, so that the latter may be entirely destroyed in the affected area. More frequently necrosis occurs in the tubercular new-formation before the bone is entirely destroyed. The form of necrosis is caseation, and in a case of any standing the presence of the disease is evidenced by the presence of yellow caseous matter occupying a certain portion of the cancellated tissue. This is shown in Fig. 420. In this area there are the thinned remains of the bony trabeculæ, which are also necrosed. As the disease is an advancing one, the more recent affection will extend beyond the caseous area.

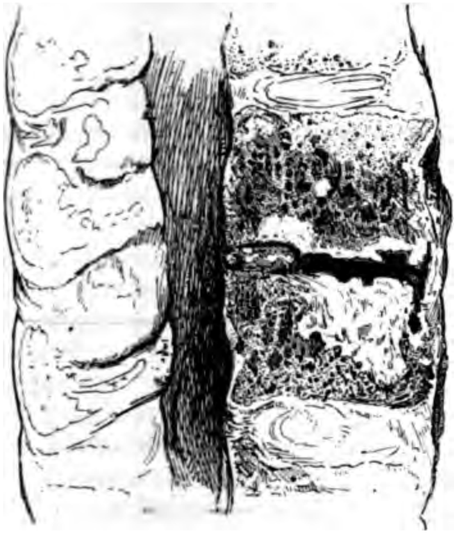
Fig. 420.—Tuberculosis of vertebræ. The intervertebral cartilage is destroyed, and the disease, as shown by the white colour (due to caseous necrosis), is invading the bodies. In the upper there is a small isolated patch.

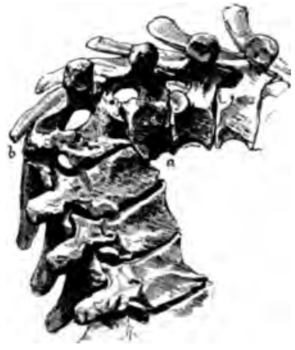

Fig. 421.—Acute curvature from tuberculosis. The bodies of two vertebræ have been destroyed, while the ones above and below have coalesced at *a*. The spinous processes are also anchylosed.

The bone so affected has lost much of its mechanical power of resistance, so that in the case of the vertebræ the bodies collapse and lead to acute curvature, as in Fig. 421, while in other cases the bones are eroded and worn down by the friction at the joints. In some cases the necrosis leads to the formation of a **Cavity** in the bone. This may be from softening of the caseous tissue, but in some cases the necrosed piece is separated as a kind of **Sequestrum** which may be found lying in the cavity. In either case the walls of the cavity are lined wit tuberculous granulation tissue. In the case of small bones, such those of the foot or hand, which are thus excavated, there may be complete collapse of the bone, so that it is more or less destroyed.

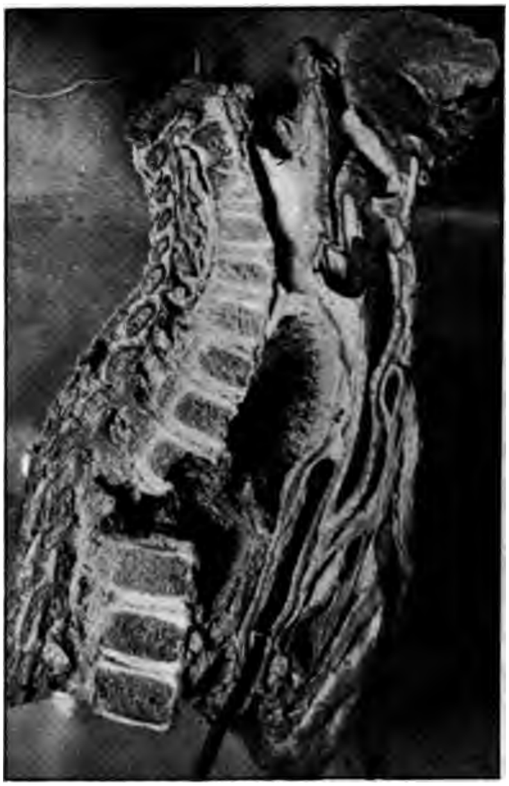

Fig. 422. –Tuberculosis of vertebræ with abscess. The trachea is laid open in front of the œsophagus. It is markedly narrowed where the aorta crosses in front of it, being there compressed between abscess and aorta. The abscess has extended upwards and downwards in front of the vertebræ, impinging on the œsophagus. Through the latter a piece of whalebone has been passed.

It is to certain of the conditions indicated above that the term **Caries** is som times applied. The characteristics of caries are, rarefaction of the bone, whic here is produced by the encroachment of the tuberculous tissue; undue softness the bone, so that it is eroded and generally exposed at an articular surface or in t wall of a cavity; the presence of caseous matter, along with prominent and flab granulation tissue, whence the name Fungous caries. (See further under Diseas of the Joints.)

The tuberculous bone is a centre of irritation, and there usual follows a suppurative process which is frequently slow in developin The resulting **Cold abscesses** (see Figs. 422 and 423) are most typical seen in connection with tuberculosis of the vertebræ. The matter, consisting of caseous debris with pus-corpuscles and serous fluid, may travel considerable distances, forming, according to the place where it comes to the surface, the **Lumbar, Psoas, or other abscess.** The whole track of the abscess is liable to be infected by the tuberculosis so that there may be an extensive tubercular surface.

Healing of the tuberculosis occurs not infrequently. It may take place before any considerable extension of the process, the tissues overcoming the tubercular infection, and ultimately absorbing the necrosed products. But it also occurs after the process of softening and formation of abscesses. In that case when the tuberculous matter has been cleared out, healthy granulation tissue will be produced. This may produce new bone, so as to some extent to regenerate and replace that which has been lost. Where there has been much erosion or collapse, the new formation will do little towards restoration, and will rather tend to fix the bones by **Anchylosis** in the position which they may have assumed. In Fig. 424 for example, the anterior parts

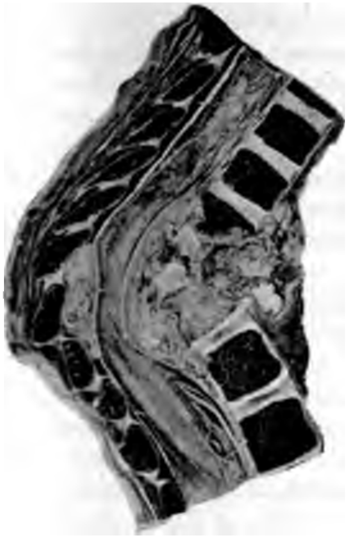

Fig. 423.—Tuberculosis of dorsal vertebrae with abscess formation and pressure on the cord. From an infant.

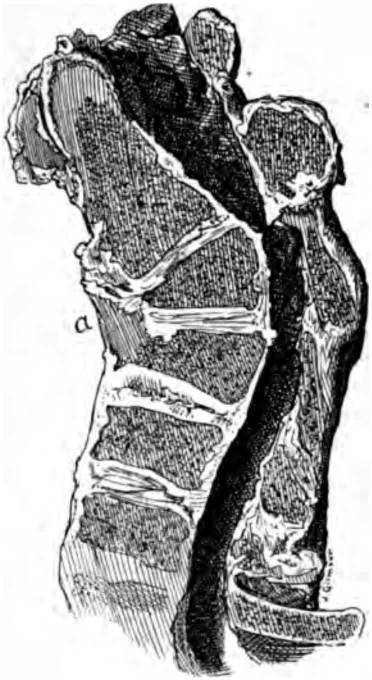

Fig. 424.—Healed tuberculosis. The bodies collapsed anteriorly. Dense bone produced at *a* to form a support. Permanent curvature and narrowing of spinal canal.

of the bodies of the third and fourth cervical vertebræ have been destroyed and a piece of dense bone (at *a*) has been formed to act as a support. This has confirmed the acute curvature which is shown by the direction of the spinal canal. In Fig. 421 also, there has been a complete collapse of two bodies, whose spinous processes have coalesced (at *b*) while the bodies of the vertebræ above and below have also coalesced (at *a*).

While healing may thus occur, the tubercular virus may still linger about the parts, and on the occurrence of a favourable opportunity it may renew its advance. In the case, for example, from which Fig. 421 was taken, the history showed what appeared to be a complete recovery (with curvature) three years before death, but a more recent onset ending in tubercular pleurisy led up to the fatal issue.

The tubercular process is accompanied by the ordinary phenomena of chronic inflammation, so that in the neighbourhood there is usually new-formation of bone, chiefly subperiosteal, and the surface of the bone may be rough with irregular projections.

2. **Syphilitic affections of bone.**—The **Lesions** of tertiary syphilis have usually their seat of origin in the periosteum, although the subjacent bone may be simultaneously involved. The condition may be briefly described by stating that gummata are produced, while inflammation occurs in the neighbourhood.

Gummata of the usual structure are produced in the internal layers of the periosteum, and there is thickening of the periosteum around. This membrane being tightly stretched over the tumour, the swelling is hard to the touch, but often possesses a certain elastic resistance. The gumma undergoes caseous necrosis in its central parts, but advances peripherally, and as it advances against the bone it causes erosion of it. The advance is in the first instance along the vessels, and as erosion occurs around them a worm-eaten appearance is produced in the bone. Beneath the gumma, which has most frequently its seat on the bones of the skull, especially the frontal bone, there may be thus considerable loss of substance, so that even the entire thickness of the skull may be penetrated (Fig. 425). The caseous material often undergoes softening, and suppuration ensues; there may be very obstinate and even progressive ulcers produced. Without ulceration the gumma may undergo resolution, and a cicatricial depression result, or after ulceration healing may occur.

Along with these processes immediately related to the gumma, there are, in the neighbourhood, conditions referable to inflammation. The bone around is condensed by new-formation filling up the medullary spaces, and there is sometimes a thickening of the bone by subperiosteal inflammation. This is much less common in the skull than in the long bones, especially those of the legs, where it sometimes leads to a very striking hypertrophy of the bone, whose surface is exceedingly rough from the loss of substance in some parts, and the irregular new-formation in others. The bone around the syphilitic defect or ulcer is dense bone, and in this respect contrasts very markedly with that around the ulceration in tuberculosis.

Congenital syphilis leads to important changes in the bones, which, according to Wegner, occur in a large proportion of syphilitic fœtuses.

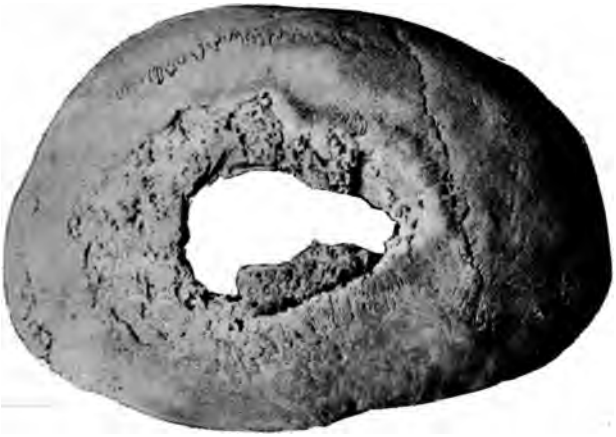

Fig. 425.—Necrosis of parietal bone in syphilis.

The lesions affect the structures concerned in the processes of ossification, and in this respect resemble those of rickets, but they partake more of the inflammatory character, thus agreeing with the lesions of hereditary syphilis generally (see p. 183).

In the **Cranial bones** the periosteum is thickened by inflammation, and this leads to softening of the bone beneath. **Craniotabes** is a frequent result, the bone being lost in parts exposed to pressure when the child is lying, and the brain being so far covered only by the soft parts.

In the **Long bones** the ossifying border is the part affected. The cartilage cells undergo excessive proliferation, as in rickets, and there is an irregular calcification of the matrix. Beneath this the proper ossifying zone frequently shows a new-formation of granulation tissue or pus, so as to produce a soft layer almost interrupting the continuity of the bone. There may be a partial necrosis of the calcified cartilage. The whole process occurs very irregularly, the ossifying part of the bone being swollen and occupied by calcified and proliferating cartilage and inflammatory tissue, while true ossification is delayed and occurs irregularly. A not infrequent consequence is a partial fracture of the bone or a **Separation of the epiphysis.**

The disease affects many bones, but may present different degrees. According to Wegner the usual seats, in order of frequency, are, the lower end of the femur, the lower ends of the bones of the leg and forearm, and the upper end of the tibia.

3. **Actinomycosis in bone.**—This affection occurs in the bones of the face, and sometimes, by extension, in the vertebræ, sternum, etc. The lesions somewhat resemble those of tuberculosis, the new-formed granulation tissue opening up the bone and leading to caries. The granulations, however, are more exuberant, and there is no caseous necrosis, but rather a tendency to suppuration.

Literature.—*Tuberculosis.*—NELATON, L'affection tuberculeuse des os, 1857; VOLKMANN, Arch. f. klin. Chir., iv.; MENZEL, Die Haüfigkeit der Caries in den verschied. Knochen, ibid., xii.; FRIEDLÄNDER, in Volkmann's Sammlung, No. 64; SCHÜLLER, Ueber die Entstehung d. tub. Gelenkleiden, 1880: VINCENT, in Internat. Encycl. of Surg., vi., 1886 (with French literature); KÖNIG, Die Tuberculose d. Knochen u. Gelenke, 1884; KRAUSE, idem, 1891. *Syphilis*—VIRCHOW, Krank. Geschwülste, ii., 1865; CANTON, Path. Trans., xiii., 1862; RICORD, Traité des malad. vénér., 1851; LANG, Vorles. üb. Syph., 1896; WEGNER, Virch. Arch., l., 1870; STILLING, ibid., lxxxviii., 1882; MÜLLER, ibid., xcii., 1883; PARROT, Arch. de Phys., iv., 1872; CORNIL et RANVIER, Man. d'hist. path., i., 1900.

X.—SPINAL CURVATURES.

Introductory.—The spinal column is composed of vertebræ whose bodies are separated by elastic fibro-cartilages. The vertebræ articulate with each other at four other points, two on the upper and two on the lower surface of the arch. They are also bound together by firm ligaments in front of and behind their bodies. The effect of these various connections is that, even when the spine is separated from all its attachments except the ligaments, it retains its general form, and its natural conformation may be studied after its removal from the body.

When seen in profile the spine presents the well-known antero-posterior curves, the convexity being forwards in the cervical and lumbar regions, and backwards in the dorsal. These curves are capable of considerable variation in the movements of the body. The whole of the curves may be obliterated and converted into general convexity backwards by stooping forwards, as when, with the arms extended and the legs straight, an attempt is made to touch the toes with the tips of the fingers. By arching the body backwards the dorsal curve may be partially obliterated, and a general convexity forwards produced. It appears, therefore, that spine is capable of considerable antero-posterior movement. These antero- terior movements imply a considerable degree of compressibility of the inter- ebral cartilages. The combined cartilages occupy about a fifth of the entire gth of the spinal column, and their compressibility may be inferred from the that during the retention of the erect posture the entire length of the column dually diminishes, so that the stature is usually half an inch to three-quarters at night than in the morning. This is believed to be due chiefly to the com- ssion of the cartilages, which recover at night when the recumbent posture is umed. The antero-posterior movement of the spine is freest in the cervical and bar regions, and most limited in the dorsal.

The spine is capable to a much more limited extent of lateral movement. The iculating processes, being situated on either side of the arches, prevent any siderable lateral deviation, as they become locked against each other when that urs. If the surfaces of these processes were horizontal, facing one another ve and below, then they might allow of freer lateral movement, but the more y assume the perpendicular position, and the more they face inwards and twards, the greater is the impediment to lateral movement. It will be found t on passing from above downwards the articulating surfaces assume more and ore of a perpendicular position. In the cervical region they are oblique, and face ghtly inwards and outwards; in the dorsal they are more perpendicular and face arly forwards and backwards, while in the lumbar region they are nearly per- ndicular, and face each other nearly inwards and outwards. In this way it curs that while lateral movement is limited in all regions it is almost impossible the lumbar region. For a similar reason, twisting of the spine on its axis is ossible to a very limited extent.

The question of the existence of a natural lateral curvature has been a matter of ispute. It is generally stated that there is a slight lateral deviation to the right the upper dorsal region, and this is usually ascribed to the more frequent and rcible exertion made with the right arm; but the existence of this curve has been riously questioned (Adams). The late Dr. Foulis in 110 post-mortem examina- ons found lateral deviation in no less than 58 cases. He did not observe it ecially in the upper dorsal region or towards the right, and concluded that it was e to the positions habitually assumed by the persons at their various trades. We ay perhaps conclude that normally there is no lateral curvature, but that a very ight permanent deviation is often assumed when a frequently repeated position of e body predisposes to it.

Forms of spinal curvature.—The function of the spine is to support he structures attached to it, and to hold the head erect, the latter unction being in man the more prominent one. Any single curvature f the spine will have the tendency to remove the head from the erect osition, and tilt it backwards or forwards or to one side, and in order o preserve the erect position there is required a curvature in the pposite direction. The natural antero-posterior curves are in this sense mutually compensatory, the lumbar restores the position lost by the sacral curve, and the cervical that of the dorsal. When abnormal curvatures occur there is a tendency to a similar compensation, so that these curvatures may be divided into **Primary** and **Secondary**. It will not be necessary to consider in detail the secondary curvatures; their amount and direction may be inferred from those of the primary ones. It may be stated, however, that there are, frequently, several secondary or compensating curves, the spine presenting several sinuosities in order to reach the stable position for the head.

1. **Antero-posterior curvature.**—There are two quite distinct forms of antero-posterior curvature, the curve in the one form being rounded, and mainly an exaggeration of the natural curvature, and in the other sharp or angular.

(*a*) **Angular curvature. Pott's disease of the spine.**—This depends on disease or injury to the bodies of the vertebræ. For the most part it is a **Local tuberculosis** of one or more of the bodies with the caseous necrosis and caries described above (see Fig. 421). The softened bodies of the vertebræ give way under the superincumbent weight, and the spine is bent at a sharp angle, the spinous processes becoming unduly prominent behind. The affection of the bodies may be unsymmetrical, and if collapse be more at one side than the other the angular curvature will not be exactly antero-posterior.

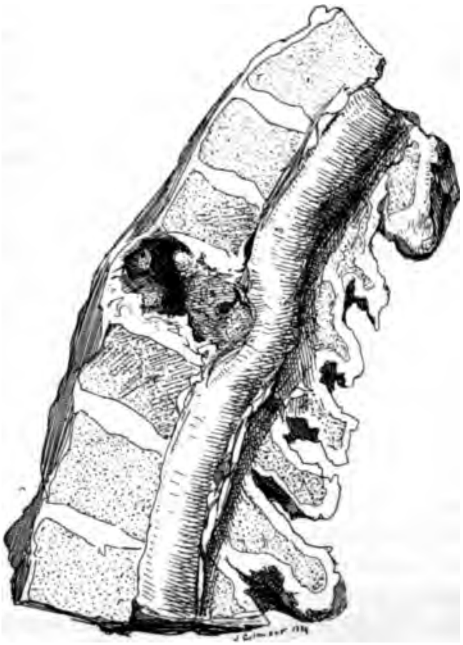

Fig. 426.—Vertebra crushed and part of it displaced backwards so as to injure the cord. There was acute curvature and paralysis. (The curvature is not shown in figure as the parts have been replaced so as to display the lesion.)

This form of curvature is more rarely due to traumatic causes, as crushing of the bodies by heavy weights falling on the head or back, or by a fall from a height. This condition is shown in Fig. 426, where a vertebra is seen crushed and with part of it displaced against the cord. This may lead immediately to an angular curvature.

It is worthy of special notice that angular curvature is much more obvious in the dorsal region than elsewhere, as it here increases the natural posterior curvature. In the cervical and lumbar regions, whe

rexity is forwards, there may be a rounded posterior
:ed, or, even with extensive disease, there may be very
ırvature visible externally.

rd is not necessarily injured by angular curvature,
ses it is crushed and interrupted. It may be so
process of healing, the sclerosis or condensation of
ıetimes causing further shrinking and increase of the

ı **Posterior curvature.**—In angular curvature the con-
rds, and the name kyphosis is sometimes applied. The
ımonly employed to indicate a more gradual rounded
ı is mainly an exaggeration of the normal curvature
ty backwards in the dorsal region, and is due chiefly
ıkness or a habit of stooping. It is most frequent
old people, leading in its most exaggerated form
ı condition, however, which is more frequently the
ı curvature), and in a lesser degree to round shoulders.
ı **Anterior curvature.**—In this condition the convexity
forwards, and the tendency of it is to throw the head
is most common in the lumbar region, and in the
ı is due to rickets. Rickets when it affects the pelvis
n to assume a more horizontal position than normal,
etain the erect position the lumbar anterior curve is
; may also be produced by congenital dislocation of the
by Adams to be of considerable frequency), and
ı hip. There may be also, but rarely, a direct lordosis
gion from rickets, the natural curvature being increased
e softness of the bones. In the dorsal and cervical
is very uncommon.

rvature, Rotatory curvature, Scoliosis.—In the intro-
ubject we have seen that the mechanism of the spine
ingly limited lateral deviation. But it often happens
ual faulty positions at work or otherwise there is a
ted tendency to lateral deviation. In that case, as a
ent is not possible, there may be, especially in persons
weak, a deviation with partial **Rotation** of the vertebræ.
ion may be merely the result of a bad habit, of stand-
or instance, so as to cause obliquity of the pelvis; or it
itting in a constrained position at study or manual
either the pelvis is oblique or the arms are used
one direction so as to displace the centre of gravity
there may be a hysterical contraction of the muscles

of the scapula lasting for a long period and altering th
gravity; or there may be an obliquity of the pelvis fr
being shorter than the other, as sometimes in rickets. Tl
softening of the bones in rickets, and very considerable ca
occur when this is associated with obliquity of the pelvis.

The mechanism of this rotation will be understood from
panying diagram (Fig. 427). The dark outline indicates
position of the vertebra, the dark straight lines indicating
axis and the direction c
verse processes. Wh
occurs the bodies of tl
move round so as to pr
side in the direction of t
and *a a*, while the spin
deviates very little. Ii
the centre of rotation is
the tip of the spine, a
a slight deviation of i
centre of rotation may
tip of the spine, and
marked rotation of th
there may be no devia
spines.

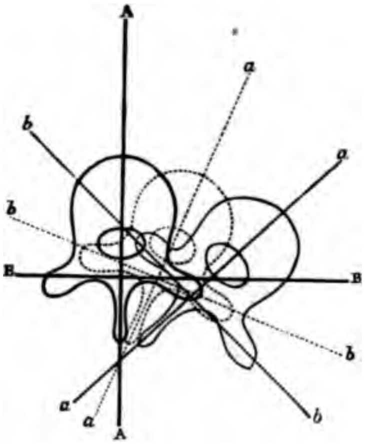

Fig. 427.—Diagram showing rotation of vertebra in lateral or rotatory curvature. The various lines show the positions of the body and transverse processes in the different degrees of rotation. The axis of rotation is behind the tip of the spinous process, where the three lines meet. (Adams.)

Lateral rotatory curve
with chiefly in the
lumbar regions, being,
much more extreme in
probably from the greater mobility there (see Fig. 428).
usually curvature in both these regions, the two curve
opposite directions, and one of them in a certain sense sec
is not possible, however, to distinguish rigidly between p
secondary curves, as the two form nearly *pari passu*; a sligl
to one side will result in a similar curve to the opposite sid
will increase together.

We have seen above in connection with Fig. 427 that t
the transverse processes is altered by the rotation of the ve
examination of that figure will show that the transverse pr
side of the convexity is considerably displaced backwards, a
cases it may be felt projecting under the skin. If the cur
dorsal region the ribs will be similarly displaced, and thei
project. As shown in Figs. 428 and 429, the rib in that cas
makes a sharp curve at its angle, so that it is greatly flatten

he figure also shows that, in such a case, the capacity of the correponding side of the chest is greatly diminished. The vertebræ are

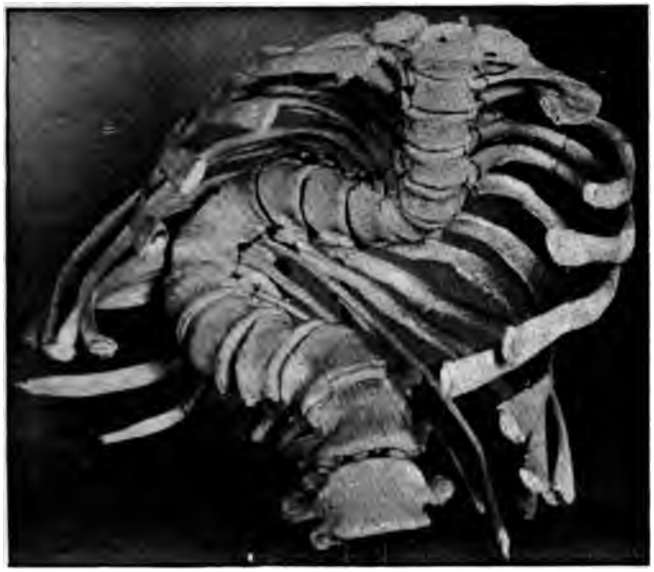

Fig. 428.—Extreme rotatory curvature affecting chiefly the dorsal vertebræ.

rotated into that side of the chest, and the ribs are flattened towards the vertebræ, these conditions sometimes attaining to such a degree

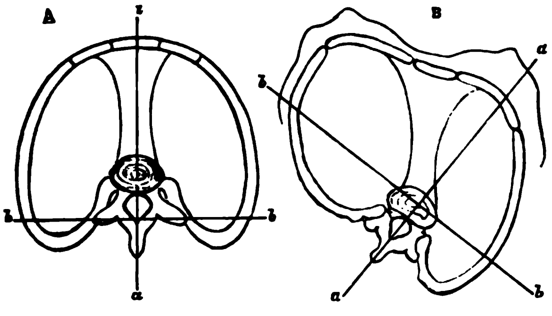

Fig. 429.—Diagrammatic section of normal chest and that with rotatory curvature. In the latter it is seen that the body of the vertebra is rotated into the right side of the chest, the rib on this side turning at an unduly sharp angle. The prominence of the transverse process on this side and of the breast on the opposite side is shown. (Adams.) This illustration may be compared with preceding one.

that the bodies of the vertebræ approach the internal surface of the ribs. There is consequently great reduction in the capacity of this side of the chest, the lung being correspondingly compressed and curtailed in its movements. It will be seen also that posteriorly there is prominence of the angles of the ribs on the side corresponding with the convexity of the curve, while anteriorly the breast on the opposite side is prominent.

The term **Spondylolisthesis** has been introduced to designate a rare condition in which, as a result of injury or inflammation, the fifth lumbar vertebra is displaced forwards so as to overhang the base of the sacrum. The vertebra carries with it the whole spinal column above it and projects into the pelvis and narrows it.

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XI.—TUMOURS OF BONE.

The tumours of bone spring from the active tissue which enters into the composition of bone, and this has been shown to be, on the one hand, the medulla, forming not only the marrow of the long bones, but occupying also the spaces of the spongy bone and the various canals of the dense bone; and, on the other hand, the subperiosteal layer, which really is formed of the same tissue as the medulla. The tumours of bone may be distinguished according as they arise from the medulla, in which case they may be called **Central or Myelogenous**, or from the subperiosteal layer when they are designated **Peripheral** or **Subperiosteal**. Originating in these structures the tumours of bone very frequently **contain bone** which is produced by a process of new-formation in the tumour itself. This applies more particularly to the fibrous, cartilaginous, and sarcomatous forms, but even in cancers there is sometimes an ossification of the stroma.

The primary tumours of bone belong to the connective tissue series, but from the near connection of some of the bones (especially the jaws), with epithelial structures, we may have tumours composed of epithelium, such as cysts and cancers, as primary tumours involving the bone. Of the typical tumours the commonest are the Osteoma, Chondroma, and Fibroma, while the Myxoma, Lipoma, and Angioma constitute rare forms. Amongst the atypical, Sarcoma in various forms is somewhat common as a primary tumour, while Carcinoma is frequent as a secondary growth. Cysts are frequent in the bones of the jaws.

Osteoma.—The osseous tumours in connection with bone have been distinguished as exostoses when they grow on the surface, and enostoses when they are central. The former are much the commoner. According to structure they are designated ivory exostoses when they are composed of dense bone, and spongy exostoses when of cancellated bone. In some of the exostoses the bone is formed from membrane, in others from cartilage, so that a layer of cartilage covers the surface of the tumour so long as it is growing. This form is sometimes called the **Cartilaginous exostosis.** (See p. 297.)

It may be added that **Multiple exostoses** are of occasional occurrence. In the case from which Fig. 430 is taken (Virchow) the patient, a boy ten years of age, had suffered, during the course of three years, from repeated attacks of rheumatism affecting the joints and muscles. The result was the formation of sixty-five exostoses on various bones of the body. Exostoses also occur not infrequently at the insertion of tendons, growing into the latter and sometimes even separate from the bones. These are connected in their origin with the contraction of powerful muscles, occurring chiefly where such muscles are inserted, and sometimes induced by specially violent exercise of the muscles.

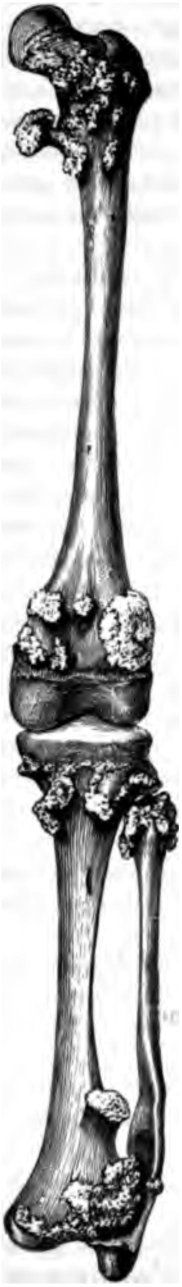
Fibroma.—These tumours are mostly peripheral, but they have been observed also centrally in the lower jaw, vertebræ, and ends of the long bones. The peripheral ones mostly occur in the bones of the face and cranium. They sometimes grow into the nares, forming **naso-pharyngeal polypi.** In structure they consist of an intricate meshwork of fibrous tissue. They do not form limited tumours, but grow out from the periosteum over a considerable area, and are firmly adherent to the bone. Trabeculæ of bone frequently traverse the tumour tissue.

Chondroma.—This occurs both as a central and as a peripheral tumour. The characters of the cartilage vary somewhat in different cases.

The central chondromata originate in the medulla, especially in the small bones of the hands and feet, and they are often multiple. They may grow till they distend and even rupture the bony shell (see p. 294, Fig. 121).

The peripheral chondromata occur on the long bones, the bones of the trunk, and those of the head. They are generally nodulated.

The name **Osteoid chondroma** has been given by Virchow to a form of tumour which merits a more special description. The tumour is composed essentially of tissue such as we find in the deep layer of the periosteum of a growing bone, or in callus, its main constituents being osteoblasts. The cells are smaller than cartilage cells and mostly



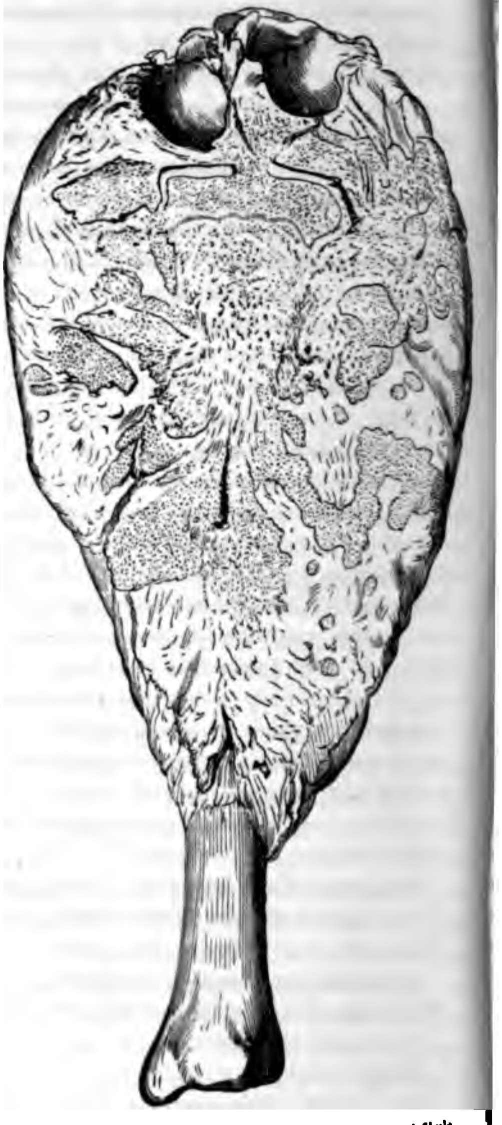


Fig. 430.—Multiple exostoses of femur, tibia, and fibula. These are grouped towards the ends of the diaphyses. At its lower end the fibula is flattened by the exostoses growing out from the tibia. From a boy ten years of age. One third the natural size. (VIRCHOW.)

Fig. 431.—Osteoid chondroma of the tibia, divided obliquely. At the upper extremity the tumour has surrounded the cartilages of the knee, and new-formed cartilages have been produced. Internally the bone is condensed by the new-formation of bony masses. From a boy 13 years of age. (VIRCHOW.)

und ; they do not possess capsules. There is a dense intercellular bstance which has a somewhat fibrous appearance. In the midst of e tissue portions of true cartilage may be found. Being formed of sue analogous to that which is preliminary to ossification it quently undergoes calcification and even conversion into true bone. ch tumours form, mostly, under the periosteum of the long bones, d their seat of election is the lower end of the femur or the upper d of the tibia, originating probably in the layer of osteoblasts there, d they may grow to large dimensions. They thus form club-shaped pansions of the long bones (Fig. 431). On section the tissue is nd to be dense, and it becomes osseous or calcareous on passing eply, where it is incorporated with the bone. The medullary cavity the bone is often filled with new-formed bone. This form of tumour metimes presents a tendency to become sarcomatous, and even with-t that it may recur after removal.

Myxoma.—This form of tumour is very rare, but cases have been served of both central and peripheral origin. The tissue is usually ixed with cartilage or other tissue. The growing tumour, whether ntral or peripheral, causes atrophy of the bone. The commonest at is the jaw-bones.

Lipoma is still more rare. Cases have been described in the upper w and tibia, and the author has recorded a case of central lipoma of rib.

Angioma.—Tumours composed of blood-vessels are very rare in the ones, but some cases are recorded in which cavities filled with blood ave communicated with vessels. These cavities have been chiefly at he ends of long bones. The cavities are variously regarded. Some onsider them true vascular tumours, others believe they are produced y rupture of arteries, and are **False aneurysms**, while others assert hat they originate from sarcomas whose vessels have enlarged. The ame **Hæmatoma** is also applied in the view that they originate in æmorrhage.

Besides these tumours, others may be so highly vascular as to be ulsatile during life. This applies especially to the soft sarcomas.

Cysts. Cystoma.—**Cysts** occasionally arise in bone by softening of he tissue of other tumours or of the bone marrow itself. Fig. 432 epresents a case in which the head of the fibula was distended by a nilocular cyst which contained serous fluid and was lined by a ascular membrane.

Cysts of the jaws merit special attention. These originate for the most part near the alveolar processes, and are probably related to the teeth. Some of them are single, **Unilocular cysts**, and have their origin in teeth which have not undergone the usual eruption. A tooth or pieces of hard substance (dentine) are usually present in the wall of the cyst. Others are **Multilocular** and develop out of a gland-like tissue, the cells of which undergo colloid degeneration, and in this way form cysts. In its original structure the tumour might be called an adenoma, and a considerable portion of it is sometimes composed of solid glandular or epithelial tissue. According to Eve the tumour arises by penetration downwards of the epithelium of the gums, and he compares this to the normal penetration of this epithelium in the fœtus in order to form the enamel organ. These multilocular cysts are mostly innocent, but sometimes the epithelium is less regularly arranged, and they approach in structure and tendencies to the cancers. Both forms of cysts originate in the interior of the jaws and distend them; those in the upper jaw have a special tendency to pass into the antrum which they may fill out.

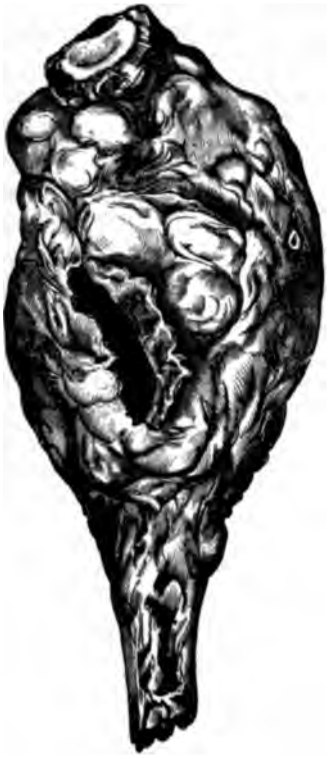


Fig. 432.—Cyst of upper end of fibula. The upper part of the bone is expanded into a cyst which contained a reddish serous fluid.

Sarcomas.—These form the most important group of tumours of bone. They are divisible into central and subperiosteal forms.

The Central or Myelogenous sarcomas occur in the lower jaw and in the cancellated tissue of the long bones, especially the femur, tibia, and humerus. They present a somewhat varied structure. Many of them are giant-celled or **myeloid** sarcomas (see Fig. 177, p. 340). Some are composed of **large round cells**, which may resemble epithelial cells, some are **spindle-celled**. There are also cases in which large cells exist in nests forming an **alveolar sarcoma**, which resembles cancer.

The central sarcomas, originating in the bone-marrow or in the substance of the bone, destroy in their growth the bone-tissue. In this way they frequently work their way to the surface, destroying the continuity of the bone. **Spontaneous fracture** is the result. This ll seen in Fig. 433, which represents the upper part of a central yeloid sarcoma. Below there is a bulky tumour distending the lower d of the femur (not shown in figure). A spontaneous fracture has curred and the upper fragment is shown. The tumour is growing in e medullary cavity of the shaft and has eroded the bone on either side that the dense bone tapers off. The fracture has been thus produced.

In some cases the sarcomatous tissue almost entirely replaces the proper bone, e condition suggesting a new-formation in the entire medulla. This is strikingly e case in a preparation in the Museum of the Western Infirmary, Glasgow. ere the entire humerus is replaced by a bulky tumour consisting of round d spindle-shaped cells, no trace of the bone persisting except the condyles. he arm was amputated, but a precisely similar tumour developed in the other merus, which was also amputated.

The Subperiosteal sarcomas (Peripheral sarcomas, see Fig. 434) are iefly round-celled or spindle-celled, but in the case of the jaws they ay be giant-celled. The tumour may enclose a considerable portion the bone, especially in the case of the long bones, and may present a mewhat radiating arrangement from the shaft. The growing tumour liable to erode the proper tissue of the bone, as shown in Fig. 434. he tissue is very liable to undergo ossification. In some the ossifica-ion is so striking a feature that the whole tumour is represented by a ass of dense bone, on the surface of which the sarcomatous tissue is resent as a comparatively thin layer. To this form the term **Osteoid arcoma** may be applied. The cells on the surface of this tumour are ariously shaped, and the bone seems to arise directly from these cells, hich act as osteoblasts.

The sarcomas of bone show very varying degrees of **Malignancy**. hey grow locally at the expense of the bone as in Figs. 433 and 434, d not infrequently encroach on neighbouring structures, sometimes netrating into the joints. Many of them show merely this local alignancy, but others extend by metastasis to internal parts. Even e highly ossifying forms may lead to secondary tumours in the lungs, d secondary tumours showing a similar ossifying tendency.

Carcinoma.—A primary cancer can scarcely originate in bone, where ere are no epithelial elements. In the jaws, however, we meet with hat are practically primary cancers. The near connection of the jaw-ones with the gums and with the teeth, whose enamel organ is an pithelial structure, explains the origin of such tumours. Cysts of the ntrum have been already referred to as frequently originating in denoid tissue, and this tissue may take on a cancerous character. In oth jaws, also, cancer, originating at the alveolar surface, may grow nto and involve the bone. Cases are not uncommon in which a cancer has originated in connection with an old discharging cloaca, the result of necrosis. The cancer extends into the sinus, and even into the cavity of the bone.

Secondary cancer is very frequent in the bones. Cancer, when it becomes generalized, is very liable to become implanted in the cancellated tissue, especially of the vertebræ, ribs, and ends of the long bones. It there grows as a central tumour, distending and destroying the bone, and sometimes leading to spontaneous fractures as in Fig. 435. In most cases the tumours are multiple. The stroma is sometimes composed of bone and cartilage so that the tumour may be hard.

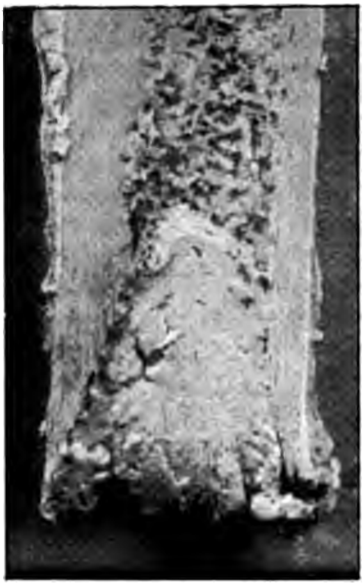


Fig. 433. Upper part of a central myeloid sarcoma of femur in section. The tumour was growing in the medullary canal and had eroded the bone on either side.

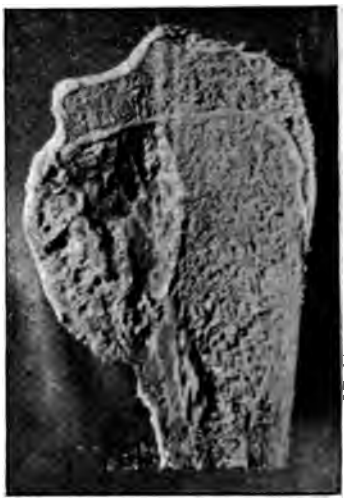


Fig. 434. Spindle-celled sarcoma of tibia growing from upper end of diaphysis. It is eroding the bone.

Secondary thyroid adenoma is a rare form of tumour in bone. A few cases have been observed in which, with enlargement of the thyroid, secondary tumours composed of glandular tissue have developed, chiefly in the bones of the skull and vertebræ. In a case observed by the author the tumours occurred in the diploë of the skull, and in growing destroyed the bone. One of the tumours in the occipital region caused a gap in the skull an inch and three-quarters was occupied by the tumour which projected formed during life a bulky Pulsatile tumour.

Parasites in bone.—The **Cysticercus** cellulosæ has been observed. Targett has given a good account of **hydatids in bone**. This disease, due to the echinococcus, is very rare in bone. The cysts develop either in the substance of the bone, more particularly the ends of the long bones, the bodies of the vertebræ and the pelvis, or they develop inside a natural cavity such as the frontal or sphenoidal sinuses, this being much less common than the other. The lesion is usually a diffuse one; there is no mother cyst, and the hydatids bud out, forming an **exogenous** growth. After growing and distending the bone it may burst through it and develop further in the soft parts around.

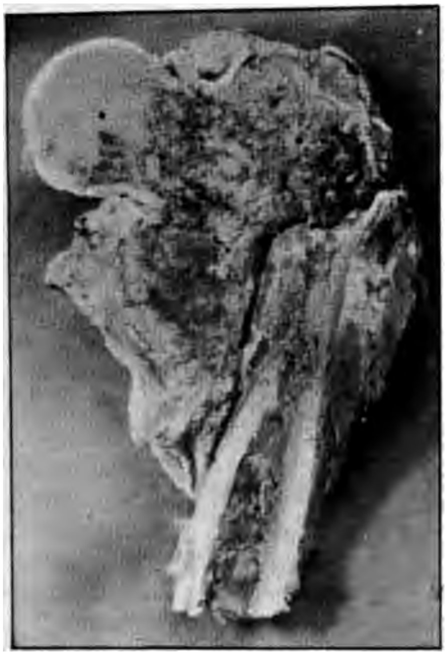


Fig. 435.—Spontaneous fracture of neck of femur from a secondary cancer.

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B.—The Joints.

I.—DISLOCATIONS AND MISPLACEMENTS.

1. **Congenital dislocations.**—Children are sometimes born with certain joints in faulty positions, some of these being really traumatic and others of more obscure origin. The traumatic cases arise for the most part during parturition, either from the natural forces engaged in delivery, or by dragging on the part of attendants. The **Hip-joint** is not infrequently dislocated in this way, and usually the displacement is double. The head of the bone is usually displaced upwards so as to rest on the dorsum of the ilium above and behind the acetabulum. Through time the head makes for itself a new joint, and the acetabulum fills up. Congenital dislocations of other joints are exceedingly rare.

2. **Talipes or Club-foot and Club-hand.**—These names are applied to distortions of the feet, or more rarely of the hands; the bones assume certain abnormal positions in which they are retained by the contraction of muscles.

Causation.—A certain proportion are **Congenital**, the child being born with one, or more commonly both feet, turned rigidly in, so as to form a **Talipes varus.** The muscles keep the foot in this position. According to Eschricht and Berg, the foot in early fœtal life is inverted, and at birth normally retains a degree of inversion, the soles being turned in. An exaggeration of this, or a retention of the early fœtal condition, constitutes a congenital club-foot.

The **Non-congenital** forms are, in most cases, due to infantile paralysis, a disease in which some muscles are paralyzed, while others are not. In some cases the deformity is due to the rigid contraction of the unparalyzed muscles, a condition to which the name **Paralytic contracture** is given. In many cases, however, the faulty position is largely due to the fact that the paralyzed muscles are not able to keep the foot in its proper position, so that it tends to fall into the attitude it would assume if there were no muscles. These positions are also variously modified by the use made of the foot in walking, the parts being brought against the ground in the position most suitable to stability in the maimed condition of the limb. In a similar way club-foot may occur in pseudo-hypertrophic paralysis.

Besides paralysis, it seems that spasm may lead to talipes, although the explanation of the local spasm is often very obscure. It is undoubted that children sometimes acquire a talipes after a convulsive attack.

Forms of Talipes.—These do not call for detailed description here. There are four principal forms, some of which may be combined.

s varus the toes are inverted, and the inner margin of the ised upwards; the tibiales anticus and posticus are the hich are chiefly contracted. In **Talipes valgus**, which is e rarer forms, the foot is turned outwards, the outer border and there is usually also some elevation of the heel; the xtensor longus digitorum, and gastrocnemius are the muscles gaged. In **Talipes equinus** the heel is raised and the ded, so that the person walks on the distal extremities of tarsal bones; the gastrocnemius is the muscle contracted. **s calcaneus** the heel is depressed, and the foot flexed at , this deformity being the reverse of the preceding one; acted muscles are chiefly the tibialis posticus, the peronei, xtensors.

retention of the fixed position **the Bones** become variously **in shape**, undergoing atrophy where exposed to prolonged Where the cartilage is no longer used in the movements of , it also atrophies. The bones frequently acquire adhesions ew positions, and the ligaments, by elongating or shortening, late themselves to the new position. New ligamentous attach- sometimes formed, and the bones may become joined together osis.

-foot.—In this condition the internal arch of the foot is so as to be in some cases abolished; at the same time the tated outwards and the astragalus is pushed downwards and he greater part of its head ultimately leaving the scaphoid. lition arises from the weight of the body stretching the , chiefly the external calcaneo-astragaloid and the interosseous stragaloid. The loosening of these ligaments allows of the ent of the astragalus, which is the essential element in the n of the lesion.

umatic dislocations.—We have here to do with cases in e bone is pushed out of its place by some external force it.

nes are kept in their places mainly by the ligaments of the t no inconsiderable aid in this regard is given by the muscles on the bones. As a general rule when external force is on a bone at a joint, the muscles are so braced up as to enable to retain its place in spite of the external force. But if a xercised on a bone unexpectedly or if the muscles are relaxed as in alcoholic stupor, then it may be displaced, the force under ordinary circumstances would be insufficient e this effect.

When the bone is dislocated, the same contraction of the muscles which normally aids in preventing dislocation, generally offers a serious obstacle to the return of the bone to its normal place.

A bone may even be displaced by the action of the muscles themselves, where a certain group acts very vigorously while their antagonists are relaxed. There are indeed persons who can produce Dislocation voluntarily of almost all the more movable joints, and that by mere muscular effort. In order that this may occur we must suppose a certain laxness of the ligaments, but there is also a power acquired by education of strongly contracting certain muscles, while others which usually contract along with them are relaxed. We know that for the most part the muscles in their contractions are co-ordinated, and most people are unable to contract individual muscles apart from their co-ordinates, but there are exceptional persons who possess this power, some in a limited degree and others very remarkably. Many persons, for instance, cannot shut one eye without shutting the other, and most persons when they shut one require to make an active effort at opening the other, in order to prevent it shutting too. But there are persons who can close the eyelids of one eye as easily as they can close the fingers of one hand.

In traumatic dislocation there is usually tearing of the ligaments to some extent, and in the case of some joints much laceration is necessary before dislocation can occur.

If restoration does not occur soon, the bone acquires adhesions in its abnormal situation, the adhesions being the result of chronic inflammation set up by the irritation of the bone. The displaced bone generally comes to press with its head against a neighbouring part of the bone with which it formerly articulated, and the adhesions attach it to the periosteum in its new position. Friction by degrees wears down to some extent the opposed piece of bone, and as new bone is produced around by the irritation there may be a kind of hollow joint formed. By the wearing of the bone the cancellated tissue would be exposed, were it not that dense bone is produced on the surface so as to cover in the spongy tissue. A smooth hollow surface may thus be produced, and even a tolerably perfect joint, although cartilage is not formed to cover it, but only a layer of smooth polished bone. The head of the displaced bone also loses its cartilage, and may even become considerably worn away. If the bone remains permanently displaced the old hollow of the joint becomes filled up, bone growing when the friction of the opposing bone is no longer exercised.

5. **Spontaneous dislocations.**—This name is applied to dislocations which occur without any considerable violence. They usually imply a previously diseased state of the joints. The disease is generally inflammation or tuberculosis, both of which soften the ligaments and alter the form of the joints.

terature.—Adams, On Club-foot, 1866; Eschricht, Deutsch. Klinik, 1851; aud, Arch. d. phys., iii., 1870; Holl, Langenbeck's Arch., xxv., 1880; ngton (Flat-foot), Jour. of Anat. and Phys., 1884-85; Kennedy (Flat-foot), g. Med. Jour., xlii., 1894.

II.—ANCHYLOSIS.

y this name is meant fixation of a joint by union of the opposing es by means of firm adhesions. The expression "false anchylosis" ometimes used to designate the condition in which the joint is fixed, by adhesion between the bones, but by rigidity and shortening of surrounding soft parts.

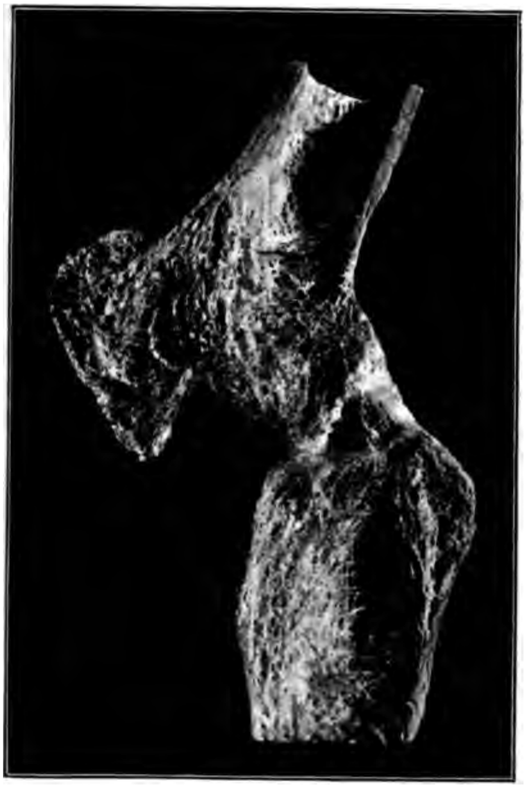


Fig. 436.—Osseous anchylosis of the knee-joint. There is well-marked rarefaction of the bones.

or the most part anchylosis is the result of inflammations of joints, re the cartilage has been destroyed and healing has subsequently urred. In the process of healing the inflammatory tissue on the osing surfaces develops into connective tissue, and as the two surfaces have to a considerable extent coalesced, fibrous tissue unites them permanently. In this fibrous bond of union there are often bony plates, and occasionally the union is effected by bone itself (see Fig. 436). In the latter case the term **Synostosis** is applied. This, however, is an unusual occurrence, as even slight movement of the joint is sufficient to prevent the formation of bone. It takes place chiefly in joints which have little movement naturally, such as the sacro-iliac synchondrosis. The fixation of the joint, however, is often so firm as to resemble an actual coalescence of the bones.

The term **Spondylitis deformans** is given to a condition in which the vertebræ are anchylosed together. There is synostosis of the arches and articular processes, while the heads of the ribs are anchylosed to the spine. The condition is a gradually advancing one, and the back becomes rigid.

III.—INFLAMMATION OF JOINTS—ARTHRITIS.

In most cases of arthritis the inflammation affects, more or less, all the structures which enter into the construction of the joint. The irritant is usually present in the joint itself, and is distributed over it, by the synovial fluid, during the movement of the joint. We may expect, therefore, that the synovial membrane and the cartilage, as they cover the surface, will in most cases be primarily affected. The cartilage, being non-vascular, is less liable to inflammatory changes than the synovial membrane, which in most cases is primarily and chiefly involved, especially in acute inflammations. But in chronic cases the irritation extends beyond these structures to the ends of the bones, to the neighbouring periosteum, and even to the ligaments.

1. **Simple arthritis.**—This condition is produced most directly by the opening of joints and the occurrence of septic decomposition in their fluids. But it also occurs sometimes by exposure to cold, from injuries, and from the extension of phlegmonous inflammations from surrounding parts.

In its anatomical details, the inflammation resembles closely that of the pleura and pericardium. The synovial membrane and cartilages are covered with fibrinous exudation, and the cavity contains serous fluid in which flakes of fibrine are visible. This fluid is sometimes very considerable and distends the joint. In this stage the disease may resolve and the joint return to its normal condition. On the other hand, especially if the joint has been laid open and exposed to decomposition, the inflammation may go on to suppuration. The synovial membrane becomes swollen and dull, being infiltrated with ımatory cells, and gradually converted into granulation tissue. ' the inflammation is very acute, we may have suppuration by the exudation of leucocytes without much change in the synovial rane. When the disease has gone on to the formation of lation tissue it is now in a subacute condition which is apt to olonged. The inflammation also extends beyond the synovial ›rane. In the cartilage the cells undergo active proliferation, and natrix breaks down; thus softening occurs, and ulcers form. ı is inflammation of the bone,—a rarefying ostitis. The ligaı also take part in the inflammation; they are softened and, the synovial membrane, take part in the formation of granulation . The periosteum is inflamed and new bone is formed, so that ılar projections occur near the ends of the bones. With all ;here is, of course, usually an abundant purulent discharge from oint, which may weaken the patient and prove fatal, perhaps amyloid disease.

;he inflammation subsides, the various masses of granulation tissue op into connective tissue, and by the contraction of this, great ty of the joint may be produced. The granulation tissue lining oint also to a great extent coalesces, and the result is a partial or lete obliteration of the joint. The bones thus become finally d by fibrous or osseous adhesions, and a permanent anchylosis is sult.

Pyæmic arthritis.—In this disease septic microbes are deposited e joint and spread over the surface by the synovial fluid. The ; is an acute inflammation with fibrinous exudation, but generally on rapidly to suppuration. It is remarkable that, when the joint l of pus, there is sometimes very little structural change in the ial membrane, the whole condition being almost confined to the -vessels from which an excessive exudation has occurred. The ımation usually affects several joints simultaneously.

ıs to be added that occasionally in **Dysentery, Diphtheria, Scarlet**, **Erysipelas,** etc., a similar acute arthritis occurs. In these disthere is a breach of a cutaneous or mucous surface and septic or microbes may find entrance. The affection of the joints is thus ır in its origin to Ulcerative endocarditis, which sometimes comes these affections.

Gonorrhœal arthritis.—An acute arthritis sometimes develops in rhœa, but the connection between the two diseases is disputed by . The inflammation is usually slight, like that in acute rheumatic itis, or it may, in exceptional cases, assume a suppurative character, that in pyæmia.

4. **Acute rheumatic arthritis.**—Like pyæmic arthritis this is due an irritant which is present primarily in the blood and affects t structures of the joints like other connective tissue structures. T result is an acute inflammation accompanied by serous and sometin by fibrinous exudation into the joint. The synovial membrane injected and swollen, but in most cases the inflammation passes without leaving any permanent change.

In exceptional cases the inflammation lingers in one or more join just as it does in the heart when the valvular structures are affect by the same rheumatic poison. In that case the chronic inflammati produces thickening and rigidity of the ligaments, sometimes w fibrous union of the bones.

5. **Gouty arthritis.**—In this disease uric acid, in the form of a ur of sodium, is deposited in the tissues of the joints. It is first deposit in the cartilage, and, according to Charc always, to begin with, at the middle the articulating surface, that being t point furthest removed from the blo vessels. The urate is sometimes in t form of stellate crystals (Fig. 437), t cartilage cells forming the middle poi of the bunches of crystals. But the s is also deposited in the matrix and oft in the form of irregular needles. It also frequently deposited in the synov membrane, and in the bones, ligamen and soft parts around the joints. Soi times the salts are deposited even un the skin, forming visible projections (so-called tophi or chalkstones).

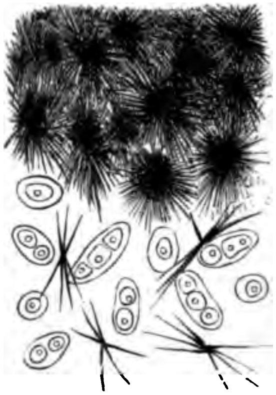


Fig. 437.—Cartilage of joint in gout, with crystals of urate of sodium. The salt is in stellate crystals which are nearly continuous at upper part of figure which corresponds to surface of joint. ×200. (Cornil and Ranvier.)

According to Moore the deposition urates is always preceded by degenerat changes in the cartilage. This author also associates gout v intimately with chronic interstitial nephritis, pulmonary emphyse and chronic inflammation of the aortic valves.

The deposition seems to lead to an acute irritation of the structu of the joint, chiefly an intense hyperæmia, often with serous exudati It never goes on to suppuration, however. Complete recovery usua takes place, but sometimes there remains a chronic inflammation, lead to stiffness and deformity of the joint.

6. **Chronic rheumatic arthritis.**—As a rule this disease affects ma *joints.* The condition is sometimes designated **Rheumatic gout.**

changes are virtually the same as in **Arthritis deformans**, and the conditions run into one another, we may describe them together. ırthritis deformans the disease is partial, being confined perhaps to ngle joint (Fig. 438), and the lesions attain a much greater develop- nt than in general articular rheumatism. It is also much more a ase of old people, and is met with chiefly among the poor. Accord- to Lane the conditions to be here described are not rheumatic in ir origin, but are the result of undue pressure and friction on the s of the bones. To this he ascribes the frequency of their occurrence ngst working people. This view is probably a partial one, but the e suggested may be regarded as a contributory element.

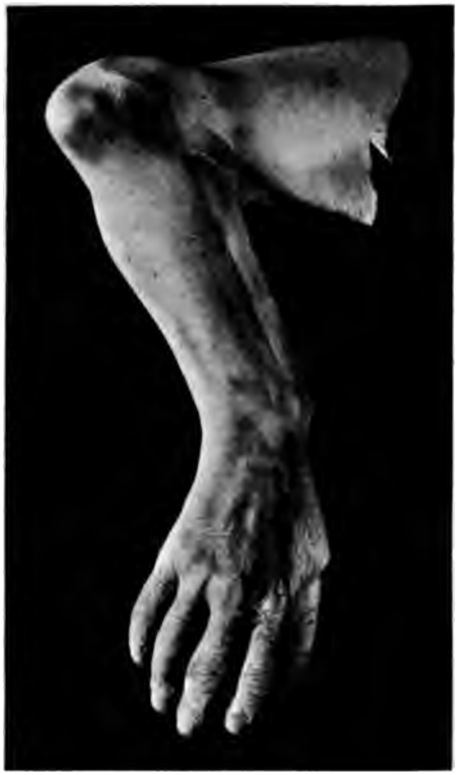


Fig. 438.—Chronic rheumatic arthritis of the elbow-joint.

ithin recent times microbes have been found in the synovial fluid several observers. Bannatyne, Wohlmann, and Blaxall have ted and cultivated a short bacillus, which they regard as the e of the disease, and Chauffard and Ramond have found a diplobacillus in the lymphatic glands in the neighbourhood of the diseased joints.

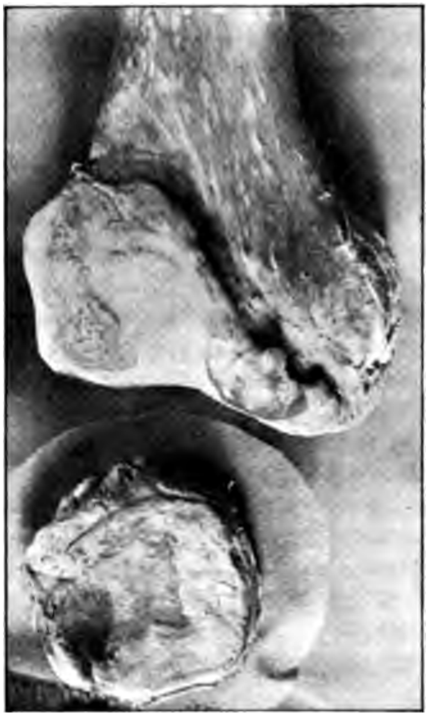


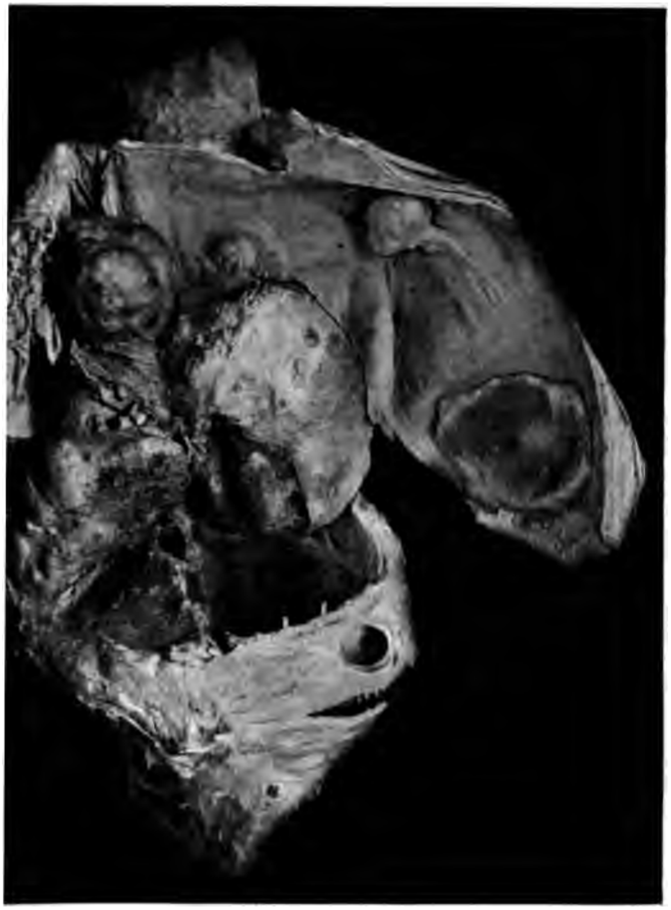
Fig. 439. Lower end of femur and patella in chronic rheumatic arthritis. In the patella the cartilage is eroded and partly replaced by an enamel-like surface. In the femur there is an enamel-like surface replacing the cartilage (especially on the left), and there is also new-formation of bone, giving the striking "lipped" appearance shown.

The inflammatory phenomena appear first in the synovial membrane and the cartilages. The synovial fringes enlarge by a slow process of inflammation, and the villous projections increase in number and become more prominent. Not uncommonly pieces of cartilage develop in the fringes, originating in the cartilage cells which exist normally there, and these pieces of cartilage, being usually pedunculated, act very much like free bodies in the joint. Portions of the prominent outgrowths may become actually separated, and so we may have loose bodies in the joints (Fig. 440). This cartilage also sometimes undergoes ossification in whole or in part. In the early stages there is usually an effusion of fluid into the joint. This is not of the character of the exudation of acute inflammation as it contains neither fibrin nor pus, but is rather of a dropsical nature. It may be of such an amount as to warrant the designation hydrops articuli, a condition which may last long.

The cartilage cells undergo proliferation and the matrix presents a peculiar fibrillation, so that the cartilage assumes a soft velvety or furry condition, and readily undergoes destruction from the friction of the opposing surfaces. This is the case in the patella in Fig. 439. It is stated by Rindfleisch that the fibrillæ of the matrix undergo mucous degeneration, and that mucus may be found in the synovial fluid.

The further changes are the result of the wearing down of the articular ends where these are exposed to friction, and at the same time the new-formation of bone at the borders of the articular surfaces.

o features are shown in Figs. 439 and 440. The altered car-
iich has a furry aspect, being worn away, the cancellated bone
ould otherwise be exposed becomes covered with a smooth,
enamel-like layer which takes the place of the cartilage.



. 440.—Advanced chronic rheumatic arthritis of the knee-joint. Observe the
ges in the articular cartilages and ends of the bones. Two pedunculated
aginous bodies are shown in the upper and right portion of the illustration.
lobular body above the condyle, to the left, was free in the joint cavity.

uliar porcelain-like surface is localized at the parts which grind
each other, and is usually found on the opposing bones of a

e edges of the articular surface the new-formation of bone some-
s in Fig. 439, takes the form of an expansion of the articular

surface, the appearance suggesting the impression that the bone had overflowed outside the proper surface. The articular surfaces may thus have a ring or everted lip of new bone, and the surface of this may also have the porcelain-like character. This new-formation of bone at the edges of the joint-surfaces is, according to Ranvier, largely from cartilage, which in the protected position at the edges undergoes proliferation and leads on to the formation of bone. There is also formation of bone in the periosteum and even in the ligaments, so that an irregular fringing of the joint with long projections may occur.

With all this there is considerable thickening of the ligaments by inflammatory new-formation of connective tissue, and often fibrous union between opposing parts of the joints. Indeed, if the joints are kept at rest, there may be a complete union of the parts around the joints opposite each other, leading to anchylosis. Without anchylosi there is stiffness of the joints, and movement is greatly curtailed.

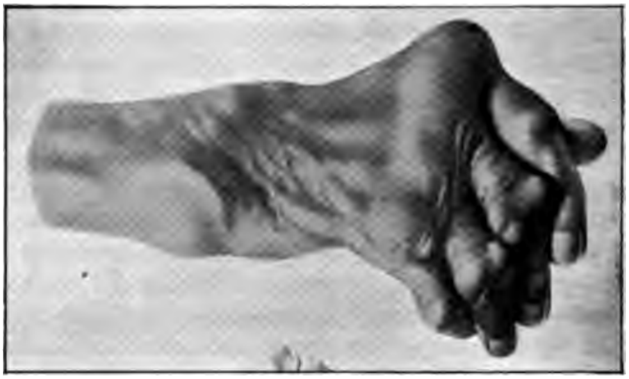


Fig. 441.—Deformity of hand from chronic rheumatic arthritis. (Robert Adams.)

The process of grinding down of the bones along with new-formation often leads to great alterations in form of the articular ends, and great deformity in the parts concerned, as is shown in the hand in Fig. 44 and in the elbow in Fig. 438. This is particularly the case in the more extreme and localized form to which the name of arthritis deformans more particularly given.

An extreme degree of arthritis deformans is sometimes seen in the hip joint, where it receives the special name of **Morbus coxæ senilis.** Here the wearing down of the head of the bone is sometimes very extreme, so that ultimately the articulating surface may lie between the trochanters. As new-formation of bone occurs simultaneously the borders of the articular surface, a kind of artificial head is produced, and the appearance is presented as if the neck were atrophied and the head displaced as in Fig. 442. In like manner an apparent widening of the acetabulum may occur. The original articular surface is worn away, but by the formation of new bone under the periosteum around, a wall is formed, giving the appearance of the borders of a widened acetabulum.

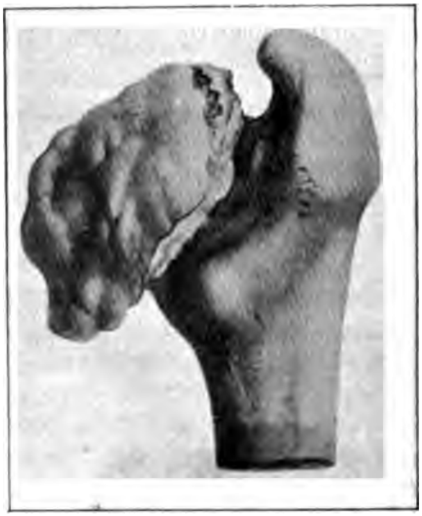


Fig. 442.—Head of femur in chronic rheumatic arthritis—the head and neck worn down and the appearance of a new head produced by new-formation. (ROBERT ADAMS.)

Charcot's disease. — This name is applied to conditions of the joints arising in consequence of diseases of the spinal cord, especially locomotor ataxia. The lesions consist in an atrophy of the articular ends of the bones including the cartilages. There is in consequence of the exposure of the bone, a wearing down of the bones, without the new-formation such as appears in chronic rheumatic arthritis. (See under Locomotor Ataxia.)

Literature.—*Rheumatic Arthritis*—ROBERT ADAMS, Treatise on rheumatic gout, etc., with atlas, 1857 and 1873; LANE, Trans. Path. Soc., xxxvii., 1886; CANTON, ibid., iii., 1851, xii., 1861; HUTCHINSON, ibid., xxiii., 1872; WILKS, Guy's Hosp. Rep., iv., 1858; ZIEGLER, Virch. Arch., lxx., 1877; WEICHSELBAUM, ibid., lv., 1872; CHARCOT, Senile and chronic dis., New Syd. Soc., 1881; BANNATYNE, Rheumatoid Arthritis, 2nd edition; CHAUFFARD and RAMOND, Rev. de Méd., xvi., 1896. *Charcot's Disease*—CHARCOT, Dis. of nerv. syst., New Syd. Soc., 1881.

IV.—SYPHILIS AND TUBERCULOSIS OF THE JOINTS.

Syphilis does not frequently attack the joints, but rheumatic attacks in syphilitic persons may have some relation to the specific virus. According to Lancereaux, there may be, in the secondary stage, an inflammation like that of acute or subacute rheumatic arthritis, and, in the tertiary stage, manifestations like those of chronic arthritis.

Tubercular arthritis.—This disease is also called *strumous synovitis*, *gelatinous degeneration* of the joint, *tumor albus*, *fungous caries*, etc. The tubercle bacillus is the essential factor in the **Causation** of the disease.

In many cases it reaches the joint after having attacked the bone, but the proportion of cases in which it does so as compared with those in which it comes directly is a matter of doubt. Tuberculosis of bone will extend to the joints much more readily in the case of some bones than others. As the head and neck of the femur are exposed in the hip-joint in immediate contact with the synovial membrane, extension very readily occurs here.

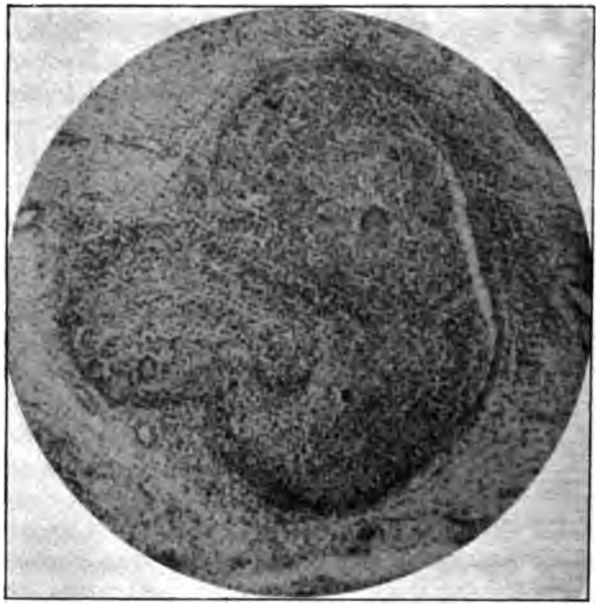


Fig. 443.—A group of tubercles with giant-cells from a case of tuberculosis of the synovial membrane. × 60.

The disease is mostly one of children, a fact which favours the vi that it generally takes origin in the bones. It is chiefly weakly childr who are attacked.

The disease begins usually in the **Synovial membrane**, and consi in a formation of tubercles and a chronic inflammation with great p duction of granulation tissue. The soft, pulpy granulation tissue gi the synovial membrane a gelatinous appearance, from which one of t names of the disease is taken. There is also a slow enlargement of t joint from the increased bulk of the synovial membrane. The pul gelatinous tissue often presents to the naked eye distinct white bodi —the miliary tubercles—and under the microscope typical tuber are visible, as shown in Fig. 443, and also in Fig. 66, p. 193.

ls of the bones constituting the joint are affected simul-
›r soon after, and here the characters presented are those of
s of bone. The medullary spaces become filled with granu-
e and enlarged by destruction of the bony lamellæ. In this
ı tissue there are also tubercles. There is thus, as it were,
anulations under the articular cartilage.

ilage also at the sides is partly encroached on and over-
the altered synovial membrane which advances over it. In
is partly enclosed between two layers of granulation tissue,
ually becomes eaten into. The granulations, chiefly those of
a, extend into the cartilage, and their encroachment is
proliferation of the cartilage corpuscles, which enlarge and
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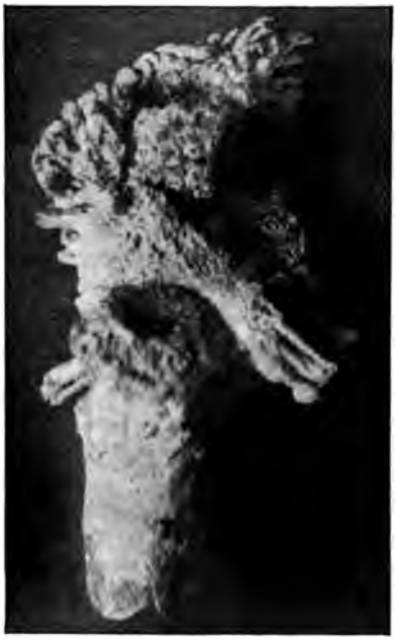


Fig. 444.—Heads of ulna and radius from tuberculosis of elbow. The parts are greatly deformed by caries and by the new-formation of bone in the form of osteophytes.

ing of the two ends
es, which are now covered by granulations, leads to an
destruction of those soft structures. The inflammation
re deeply in the bone as the superficial parts are ulcerated,
have progressive caries. For some distance beneath the

surface the medullary spaces are filled with granulations and the bony trabeculæ thinned. It will be understood from this how the disease is apt to recur unless the whole carious portion be removed, for tubercles are present in the granulation tissue filling the medullary spaces, and unless they be removed a fresh extension may occur.

In the neighbourhood of tuberculous joints there is commonly a considerable new-formation of bone by a formative ostitis such as that referred to at p. 633. There may thus be produced irregular projections or **osteophytes** such as those shown in Fig. 444.

In an early period of the disease, before suppuration has occurred, there may be recovery ; but after the occurrence of suppuration, there is seldom a spontaneous restoration, which at best is a slow process. If recovery takes place the granulating surfaces unite more or less, and the joint being partly or completely obliterated, a fibrous union may come about, leading, it may be, to anchylosis.

The author has met with a case in which an **early and pure tuberculosis** of the synovial membrane presented peculiar characters. There was very great thickening, so that the synovial membrane was converted into a bulky soft grey tissue which overlapped the cartilages, and was so prominent that when the joint was opened for the purpose of excision, the idea of a tumour was suggested. In this case there were large numbers of the most typical tubercles, many consisting almost entirely of giant-cells and epithelioid cells.

Literature.—LANCEREAUX, Traité de la syph., 1874 ; KÖNIG, Tuberculose der Knochen und Gelenke, 1884 ; CROFT, Path. Trans., xxxii., 1881 ; WATSON CHEYNE, Brit. Med. Jour., Nov. and Dec., 1890.

V.—LOOSE BODIES IN JOINTS.

These occur most frequently in the knee joints, but also in the hip, shoulder, maxillary, and other joints. They consist generally of more or less rounded pieces of tissue, and we may have fibrous tissue, bone, cartilage, and adipose tissue entering into their composition. They are nourished by the juices of the joint and may even grow in their detached position.

The loose bodies have various origins, but usually arise by separation of pieces of tissue which may either be parts of the normal cartilage or bone, broken off by violence, or else parts of abnormally prominent structures which have in the movements of the joints been torn off. Thus the synovial fringes may enlarge by excessive growth of adipose tissue or even of cartilage in them, or by inflammatory new-formation. Again, in chronic rheumatic arthritis, the prominent bony excrescences are liable to be broken off.

SECTION IV.

DISEASES OF THE NERVOUS SYSTEM.

m.—The plan of the nervous system in general.
ripheral Nerves. Anatomical introduction. 1. Effects of injury and
m of nerve stems. 2. Neuritis: (1) Multiple neuritis—(*a*) from lead;
m arsenic; (*c*) from alcohol; (*d*) in acute specific fevers, etc. (2) Local
is (*a*) by continuity; (*b*) leprous; (*c*) syphilitic. 3. Tumours.
pinal Cord and Medulla. Anatomical introduction. I. **Secondary
erations.**—Causation; character of lesions, grey degeneration, sclerosis.
—1. Descending grey degeneration. 2. Ascending grey degeneration.
generation after amputations. II. **Inflammations.** *A*. **Transverse
is.** 1. Acute; acute softening. 2. Chronic; chronic compression.
ers' paralysis. *B*. **Systematic Myelitis.** General causation. 1. Sclerosis
terior columns; nature of changes and relation to function. Hereditary
. 2. Spontaneous or primary lateral sclerosis. 3. Postero-lateral
sis. 4. Acute ascending paralysis. 5. Poliomyelitis anterior acuta.
liomyelitis anterior subacuta. 7. Poliomyelitis anterior chronica or
ssive muscular atrophy. 8. Bulbar paralysis. 9. Pseudo-bulbar
sis. 10. Pseudo-hypertrophic paralysis. III. **Tumours.**

NTRODUCTION.—PLAN OF THE NERVOUS SYSTEM.

T observations regarding the connections and relations of
ve cells and nerve fibres, with which the names of Ehrlich,
mon y Cajal, and Retzius are chiefly connected, are interest-
important. Nerve cells possess two kinds of processes, the
mic processes or **dendrites**, and the axis cylinders or **axons**
ns). Each process ends by arborescent branches. When
ls communicate with nerve cells it is not by direct communi-
their processes, but the arborescent endings articulate with
orescent endings, or else form a reticulum around the cells
es and so influence them. This mode of connection is called
r a **synapsis** (σύν and ἅπτω = I clasp). Each cell with its pro-
wn to their final arborescences is independent and constitutes
nerve tissue (the neurone of Waldeyer). Nerve cells may, in
by means of their processes articulating with the processes of

other cells, be brought into relation with many other cells. The arborescent expansions are thus the recipient parts of the nervous system. The grey matter of this system contains the cell processes with their ramifications and expansions, and the white matter is the prolongation of axis cylinders, which again are processes of the cells and therefore parts of the cells.

The nutrition of nerve cells and their expansions is, like that of other cells, dominated by the nucleus, and when a process is cut off from the nucleus it suffers in its nutrition.

The simplest idea of a nervous system is that of a central ganglion with afferent or centripetal fibres and efferent or centrifugal ones. An approach to this simplest form of nervous system is afforded us in the case of the heart. We have here in the substance of the organ certain ganglia, which possess on the one hand centripetal fibres coming chiefly from the endocardium, and on the other hand centrifugal fibres passing to the muscular fibres of the heart. It is to be presumed that impressions conveyed from the endocardium induce the development of impulses which are conveyed by the centrifugal fibres to the muscle and bring about its contraction.

But these intrinsic ganglia of the heart, although forming with their connections a complete nervous system, are not entirely isolated and independent. They are under the command of higher centres which control their action and through them affect the contractions of the heart. From these higher centres fibres reach the heart by two paths, by the vagus and by the sympathetic, and by means of these fibres the action of the intrinsic ganglia is restrained or stimulated.

Taking a general survey of the nervous system, we find that, among the innumerable centres, there are grades or orders to be recognized, the lower or simpler being under the control of the higher and more complex. Leaving aside the peripheral centres and the sympathetic system, we may fitly illustrate this in the case of the cerebro-spinal axis.

In the **Spinal cord** there are, chiefly in the anterior cornua, groups of ganglion cells which form distinct individual centres. Many of these appear to be of the simplest kind, representing, as it were, single muscles or limited groups of muscles. The stimulation of such simple centres would produce no properly co-ordinated movements, but simply the contraction of a muscle or muscles. But in the cord itself there are centres of a higher order than this, representing, not single muscles or very limited groups, but more considerable groups of associated muscles, so that movements of some complexity are brought about by their stimulation. The centres of lower order are under the control of

er, and it is to be presumed that the·higher, in bringing about
nts do not act directly on the muscles, but stimulate in the
ance the lower centres, which then act directly on the muscles.
e higher centres in the cord are, as compared with those in the
a very low order, and are only capable of effecting such simple
s the extension of the toes, the drawing up of the leg, etc.
edulla oblongata may be regarded as simply an extension
of the spinal cord. Its centres are scarcely of a higher order
se of the cord, and the movements which may be effected by
are of the simplest character. In it are massed the great
hich have the control of the respiratory movements, and the
ion and dilatation of the blood-vessels. The muscles of the
mouth, pharynx, etc., are represented here, as are those of the
s, and trunk in the spinal cord.
g to the centres next in order above the cord and medulla
a we reach the so-called **Middle brain**, including the centres in
varolii, the corpora quadrigemina, and, as perhaps of a still
rder, the **cerebellum**. Many animals can go through very
movements when deprived of all parts above this middle
A pigeon can fly, a frog can leap, and a rabbit can run. There
ver, a want of spontaneity in the movements, which present
the characters of complex reflex or automatic actions. A
ill remain quiet till its foot is pinched, and will then set about

The movements effected by means of the middle brain require
n of the same muscles as those in which the spinal cord alone
ned, but the combinations are more complex and the grouping
uscles more intricate. In effecting these more complex move-
e higher centres act in the first place on the lower, and, through
n the muscles, the lower centres in the cord being thus a
y link in the chain.
n the middle brain appears to be much less independent than
ower animals. In many animals, as we have seen, a stimulus
from the periphery may induce such complex acts as flying,
running, but it is not so in man. If the centres for such acts
ted in the middle brain in man they are so dependent on the
entres that when their connection with these is severed they
able to act very imperfectly. A certain degree of independence
in man by the fact that when a person, completely paralyzed
ide by the connection being divided between the middle and
ain, yawns, the paralyzed arm will often move in an exaggerated
ntirely independently of the will. Yawning is an exaggerated
on, and in order to elevate the chest the arm is stretched

upwards and backwards so as to bring the pectoral muscle into action on the chest wall. When we have command of ourselves we can control these movements, but when the middle brain is disconnected the paralyzed arm may act in an exaggerated fashion.

The **Basal ganglia** of the cerebrum form a series of centres of a very high order. When such animals as the dog and cat are deprived of all centres higher than the corpus striatum they are capable of running about, these movements being, of course, automatic. But in man, and also in monkeys, although the general movements of the body may be regarded as gathered together in these ganglia, they are not sufficient for the more complex acts of locomotion, etc. The movements of the body, although represented in a complex form in these ganglia, are represented higher up in a still more complex form, and at the same time the lower centres are less independent of these higher ones.

In **the Convolutions** of the cerebral hemispheres we have the highest order of centres and in man **the Motor area** may be taken to form the seat of all the centres which are concerned with the more complex voluntary acts. In the motor convolutions we have the movements of the body as it were written larger, occupying much more space than in the corpus striatum, and more individualized.

In regard to **Sensation,** we are not to look for a succession of centres such as we have in the case of motion. There are peripheral organs of a highly specialized character, which are engaged in the transmission of the various special kinds of sensation. Between these and the highest centres there are virtually no others interposed, the intervening structures being only concerned in conduction, perhaps with arrangements for fortifying the impressions as they are conducted through greatly elongated paths. Besides the apparatus engaged in sensation, there are afferent fibres which are related to reflex actions, and probably the same fibres to some extent subserve both functions.

In studying the various diseases of the nervous system it will be necessary to carry these physiological considerations along with us, and in the case of each disease it will be needful to take into account the effect which it will have on the physiological action.

Lesions occurring in nervous structures produce various effects. They may **irritate** the centres either directly or by means of their communicating fibres. If a **Motor centre** be irritated there will be muscular movements, such as spasms and convulsions. If a **Sensory centre** be irritated there will be subjective sensations as of sight, smell, touch, hearing, taste. If a **Mental centre** be irritated there will be subjective mental phenomena, that is, mental phenomena which are

› control of the individual, *e.g.* peculiar thoughts, illusions,
he other hand, lesions may **destroy** centres, in which case we
paralysis of motion (akinesia), or loss of sensation (anæs-
mental degeneracy.
which are large and palpable are often called **Coarse lesions,**
tumour or a clot destroys or irritates, or does both. Coarse
thus distinguished from those finer changes which are matter
opic observation. In some cases, indeed, the existence of
ical changes is a matter of inference, the anatomical demon-
them being not yet furnished.

.—An excellent exposition of the construction of the nervous system is
BERT SPENCER's Principles of Psychology, vol. i.; also in many papers
s JACKSON, whose influence in advancing the pathology of the nervous
een very great. A systematic study of the physiology of the nervous
ERRIER's excellent work, The Functions of the Brain, 2nd ed., 1886.
diseases of the nervous system, ROSS, A Treatise on Diseases of Nervous
t ed. (which contains numerous references); and GOWERS, A Manual
f the Nervous System, latest edition.

A.—THE PERIPHERAL NERVES.

l **introduction.**—A nerve stem, whether met with embedded in the
organ or lying free, is composed of one or more bundles of nerve fibres
er by connective tissue. The accompanying figure (Fig. 445) shows
arrangement of this connective tissue in a stem composed of a single
rve fibres. There is an external layer of connective tissue, the peri-
binding the whole bundle together. But inside the bundle there is
ssue binding the individual nerve fibres together and forming the
(*b*), the nuclei of which are prominently seen in the figure. In a
ade up of several bundles these also are bound together by connective
ineurium. The nerves within the skull and the nerve-roots inside the
are, in general, less furnished with connective tissue than the peri-
, and in particular the perineurium is less consistent and continuous.
fibres of such peripheral nerves are, for the most part, medullated, and
ed in the fresh state they present an opaque appearance and a double
Fig. 446 *A*. When examined in the fresh state it is only this appear-
risible, but by proper methods of preparation the constituent structures
an be shown as indicated in Fig. 446, *B* and *C*, and in Fig. 445. These
cylinder (3, Fig. 446), the medullary sheath or white substance of
, and the primitive sheath (1). The axis cylinder is the conducting
bre, and runs continuously from end to end. The medullary sheath is
a fatty substance (myeline) and is prone to undergo a kind of coagula-
ves rise to the double contour. This substance is semi-fluid, and when
re is broken up, either during life or after death, it is apt to flow out,
y have free drops of myeline which have a strongly refracting outline
. The primitive sheath is a transparent membranous tube which
re and keeps the medullary sheath together. When transverse sections

of a nerve which has been hardened and stained are examined these various constituents appear, as in Fig. 445. The axis cylinder is a coloured point in the middle of each fibre. The medullary sheath around this is transparent and colourless. The primitive sheath forms a coloured ring around the fibre.

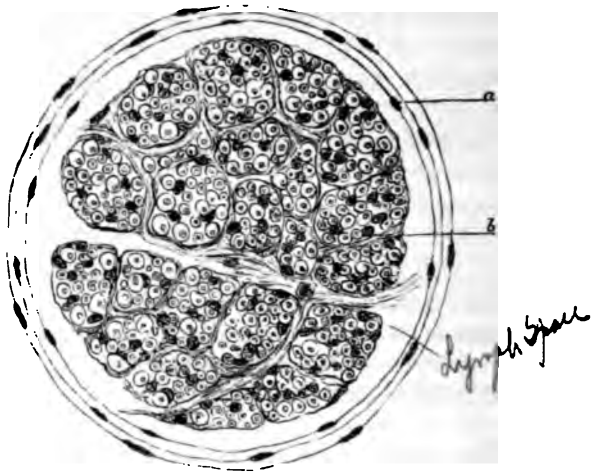


Fig. 445.—Transverse section of a nerve consisting of a single bundle; from a specimen stained and mounted by Clark's method. *a*, perineurium; *b*, endoneurium. Inside the perineurium is the lymphatic space between it and the nerve bundle. The nerve fibres are represented by rings with a central dot—the axis cylinder. × 120. (KLEIN.)

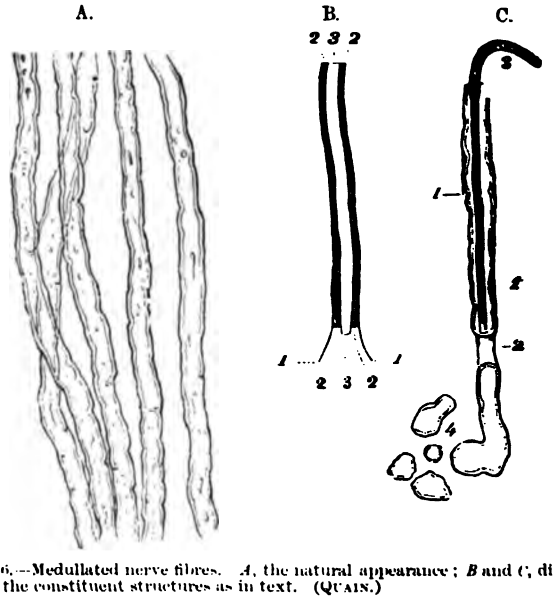


Fig. 446.—Medullated nerve fibres. *A*, the natural appearance; *B* and *C*, diagrams showing the constituent structures as in text. (QUAIN.)

a medullated nerve fibre be examined after preparation with osmic acid, it will een that, as Ranvier has shown, the medullary sheath is not continuous, but is rrupted at intervals, the axis cylinder and primitive sheath being alone present oughout. These *nodes* divide the nerve fibre into sections, and each section ives a further individuality from the fact that about its middle an oval nucleus resent inside the primitive sheath, between it and the medullary sheath.

on-medullated or pale nerves have no medullary sheath, and consist essentially axis cylinders each covered with a primitive sheath in which nuclei occur at ervals. As the white appearance of ordinary nerves depends on the medullary eath, non-medullated nerves are grey in colour. Most nerves at their perieral terminations lose the medullary sheath and become pale, but some are throughout, chiefly the olfactory nerve and the whole nerves of the sympathetic stem.

1. **Injury and division of nerve stems.**—When a mixed nerve is ided motor and sensory paralysis occur in the peripheral parts pendent on it. It sometimes happens that conduction is re-established hin a few days, and this must take place by the cut ends uniting by mediate union or by the first intention. Most frequently, however, restoration of function is tardy, and processes occur in the nerves ich have been carefully studied by experimentation on animals. The nges which ensue on the division of a nerve occur mainly in the ipheral portion of it, and they consist in the first place in a **generation** by which the structure is largely destroyed, and in the ond place in a **Regeneration** by which it is restored. The degenera- e process is often called **Wallerian,** from the observer who first idied it.

The **Causation** of this peculiar degenerative process is connected with e nutritive arrangements of the nerves. As the axis cylinders of the rves are but the prolongations of the nerve cells, they are dependent the nucleus of the cell for their nutrition. Just as any process of a ll will degenerate when cut off from the body of the cell, so do the rve fibres degenerate when divided from the nerve cells. The sensory res of the peripheral nerves are prolongations from the cells of the nglia of the posterior roots, whilst the motor fibres are prolongations m the cells of the anterior cornua, and hence the growth or degener- on of the fibres takes place in opposite directions and is under the trol of different nutritive or trophic centres. Most nerve stems sist of both afferent and efferent fibres, and the division of the stem l cut the fibres off from their cells, whether they be afferent or rent. It is important to observe that when a posterior nerve t is divided on the proximal side of its ganglion, the fibres de- erate in a central direction, or towards the spinal cord. The small t still attached to the ganglion remains intact. On the other hand, if an anterior root be divided, the proximal portion in connection with the spinal cord remains intact, while the portion distal to the section degenerates.

The changes about to be described have been studied chiefly by experimentation on animals, but similar conditions have been observed in man after division of nerves. In several diseases of nerves also, such as inflammation, leprosy, syphilis, there may be interruptions of the nerve fibres leading to lesions similar to those occurring in consequence of division, but perhaps mixed up with other phenomena.

The **Degenerative process** occurs almost simultaneously in the whole peripheral distribution of the divided nerve, affecting both sensory and motor fibres. The most obvious change is in the medullary sheath. It coagulates, breaks up into drops, and in time disappears by absorption. This disintegration of the medullary sheath occurs gradually, and the granular fat into which it breaks up is partly taken up by the nuclei of the nerve fibre, but partly also finds its way out of the primitive sheath, and is found in the surrounding connective tissue and the walls of the capillaries. There is some difference of opinion as to the part taken by the axis cylinder in the process. Erb asserts that it persists after the medullary sheath has been destroyed, but Ranvier states that it is broken up, its interruption corresponding with the abolition of electric conductivity in the nerve. Michael Foster gives his adherence to the same view. Whether the axis cylinder is destroyed or not, the nerve fibre undergoes a great transformation by the loss of its medullary sheath, and it becomes converted into a pale fibre, interrupted at intervals by the nuclei or by some persisting clumps of myeline.

It is asserted by Ranvier that the nuclei, which we have seen to exist inside the primitive sheath between every two nodes, take an active part in this process. They enlarge and divide, and, by impinging on the medullary sheath, help to break it up. It is by them also, according to this author, that the axis cylinder is interrupted. The enlargement and division of the nuclei is somewhat similar to that which occurs in muscle in certain lesions to be considered afterwards, and it is regarded as inflammatory in its nature.

At the place of division of the nerve, as there is a wound, there are signs of inflammation. Leucocytes collect between and around the cut ends of the nerve, and even penetrate into the primitive sheath for some distance. These leucocytes, which are most abundant soon after the section, attack the medullary sheath, and assist in breaking it up: the myeline is taken up by the leucocytes so as to give them the appearance of compound granular corpuscles. In the central end of the divided nerve, however, the destruction of the medullary sheath is limited, as the invasion of leucocytes generally stops short at the first node.

time the inflammation subsides largely, and the wound, in-
in and soft parts, is united by a cicatrix formed in the usual
e divided ends of the nerves are united by a pale cicatricial
ch does not as yet contain any proper nervous elements, and
ffect a restoration of the conductivity.

tion is restored by a process of **Regeneration.** According to
ches of Ranvier, this occurs entirely by the axis cylinders of
l end budding out and extending first into the cicatrix and
the peripheral end. The axis cylinder enlarges at its ex-
nd becomes divided longitudinally into several fine fibres,
w out into the cicatrix. Arrived at the cut end of the peri-
tion they penetrate into it, and very frequently pass into a
sheath. In this way a number of new-formed axis cylinders
und inside an old nerve-tube, and there may be alongside of
pieces of persisting myeline. These new axis cylinders after
uire medullary sheaths, and the regeneration of the nerve is
. According to Remak and others, the new fibres are not
tirely by budding from the central end, but arise also from
ing axis cylinders of the peripheral end. Balance's experi-
port the view that peripheral regeneration also occurs. On
hand Langley more recently has shown that provided all
rves are cut peripheral regeneration does not occur.

with the nerves the **Muscles** suffer, undergoing marked
The muscular cylinders diminish in diameter, the transverse
becomes less distinct and the fibres become granular. If
on does not occur the muscular fibres lose their transverse
rely, become much narrower, and may even present hyaline
on (see under Coagulation-Necrosis). The atrophy of the
fibres is often accompanied by an interstitial inflammation
n a new-formation of connective tissue between the muscular
kind of cirrhosis, leading, in cases where the conduction of
is not restored, to considerable shortening of the muscle and
If regeneration of the nerve occurs then the muscle is
ut there is frequently some permanent damage. The mus-
s remain partly of smaller diameter and there may be some
interstitial overgrowth of connective tissue.

re also **Trophic changes** frequently manifested **in the skin**
structures, such as will fall to be described later on as **Tropho-**
They consist of atrophy of the skin, œdema, and occasionally
ar condition described as "glossy skin" (see under Loco-
xia). There may also be affections of joints (see under
disease, p. 679).

Raynaud's disease, to which reference has already been made (see also under Diseases of the skin), is included by many among the trophoneuroses. **Erythromelalgia**, a probably allied disease or combination of symptoms, is usually placed in the same category. It is characterized by burning pain and redness, particularly of the extremities. Again, **Adiposis dolorosa** (see p. 290) has been relegated to the same class of affections. This is a chronic progressive disease characterized by irregular, sometimes symmetrical, depositions of fat in various parts of the trunk and extremities. The deposition is preceded by or attended with pain and often with tenderness. The patients are mostly women, and the affection is often associated with well-marked mental symptoms.

2. **Neuritis.**—Inflammation of nerves may be more or less general or it may be circumscribed. In the former case it invariably results from the presence of some toxic agent in the blood; in the latter it may arise from local irritation or more usually from extension of some neighbouring inflammation. When the *causa morbi* is in the blood the lesion is usually symmetrical—the nerves in both arms or legs being affected—and the inflammation appears to commence in the fine nerve fibrillæ. The large nerve trunks are subsequently affected by extension. On account of the number of nerves affected this is called **Multiple or Toxic** or **Peripheral Neuritis.**

A **local** inflammation of nerves may occur anywhere and may be limited to a small portion of one nerve in any part of its course or it may affect several nerves. It is not often symmetrical and it usually affects nerve trunks, involving their sheaths first rather than their finer fibrillæ.

(1) **Multiple or Peripheral Neuritis.**—This, as we have seen, arises from some toxic agent circulating in the blood. It may be a pure chemical product such as a compound of lead or arsenic, alcohol, nitrobenzene, carbon disulphide, carbon monoxide, etc., or it may be a toxin produced by a microbe, *e.g.* the bacillus of diphtheria, or typhoid fever. The parts affected are not identical in every case. The legs may be more affected than the arms (arsenic, alcohol), or the arms than the legs (lead), or the neuritis may be almost general, as often occurs in diphtheria. The course of the disease also varies considerably. In diphtheria it is frequently rapid; in lead poisoning it is usually slow. In all, however, similar lesions are found in the affected nerves. These resemble the early changes described as resulting from the separation of a nerve from its trophic centre (Wallerian degeneration), but as all the nerve fibrillæ are not equally susceptible or not equally acted on by the toxic agent the various stages or phases of Wallerian degeneration are often found side by side.

Owing to the stoppage of nerve impulses the muscles supplied by the fected nerves are paralyzed. As a result of this, and perhaps also as result of the direct action of the toxin on the muscle cells themselves, e muscles atrophy.

With the disappearance of the toxic agent from the blood gradual covery usually occurs, but the exact pathological process by which is results is unknown. In all probability it is similar to that occurng after Wallerian degeneration from section of a nerve.

The following are the most common forms of multiple neuritis :

(*a*) **Neuritis in lead poisoning.**—In lead poisoning the agent attacks articular nerves, and it affects the motor fibres much more than the ensory. The commonest seats of the affection are the nerves of the orearms and hands, and the characteristic symptom is "drop-wrist." This is usually bilateral, but may be more marked on one side than the ther. There is a curious omission of the nerve to the supinator longus n the affection. The neuritis is not limited to these nerves, but may ffect the nerves of the larynx, the eye, etc. The condition of the erves is that of parenchymatous neuritis, with wasting of the muscles.

(*b*) **Neuritis in arsenical poisoning.**—The neuritis resulting from rsenic has received considerable attention in recent years owing largely arsenical contamination of beer. The symptoms differ considerably om those of lead paralysis. The legs are mainly affected, and there re cutaneous and other lesions which show a severer intoxication than at resulting from lead. Arsenical paralysis closely simulates lcoholic paralysis, and by E. Reynolds the latter is believed to be in ality due to arsenic.

(*c*) **Neuritis in alcoholic poisoning.**—This has been regarded as the mmonest cause of peripheral neuritis, but within recent times some ubt has been thrown on the matter. The legs are usually the first be affected, and almost always they remain the parts most affected. e hands, however, are not infrequently influenced, and in rare cases arly the whole of the body.

(*d*) **Neuritis in acute specific fevers.**—The acute specific fevers are metimes followed by multiple neuritis. It is a rare result in typhoid d typhus fevers, is more frequent in malaria, but is especially mmon as a result of diphtheria. The neuritis seems to be the conquence of the action of the poison evolved by the infective agent and ot of the latter itself. This is proved, at least in the case of diphtheria, y the fact that the toxin obtained from cultures is capable of inducing e paralysis without the bacteria being present.

The disease known in India as **Beri-beri**, and in Japan as **Kak-ké**, is parently a multiple neuritis, due to a specific infection. It is endemic in certain localities, and particular forms of microbes have been asserted by some authors to cause it.

The poisons of tuberculosis, syphilis, and cancer may also, when present in the blood, give rise to a multiple neuritis, although these diseases are more usually associated with localized neuritis.

The condition of the spinal cord in cases of neuritis, especially in the toxic forms, has been much discussed, and there are records by Déjerine of changes in the cells of the anterior horns in cases of diphtheritic neuritis examined by him. A like condition has been found in cases of alcoholic neuritis, while atrophy of these cells has been noted also in the forms depending on lead intoxication. More recently the question has been again considered by Marinesco and Lugaro, with the aid of Nissl's method of staining, and both have found changes in these cells in such cases.

(2) **Local Neuritis.**—This is due to an agent acting locally. It may be the result of direct injury to a nerve, as by the broken end of a bone. Cold is also an occasional cause, as in the sciatic nerve. Inflammations may extend by contiguity to a nerve stem, or an infective agent may fix on particular nerves and produce local lesions. Many of these forms are chronic, and these, as in the case of chronic inflammations in general, are characterized by new-formation of connective tissue. The inflammation is in this way **interstitial**, the perineurium and endoneurium being thickened. There is consequent atrophy of the nerve fibres with the results in the nerves themselves and in the muscles which ensue on division of nerves. Several forms merit a special description.

(*a*) **Neuritis by continuity.**—Acute suppurative inflammations do not readily extend to peripheral nerve stems. A nerve may be bathed in pus, and almost isolated by the suppuration around, but there may be almost no infiltration of the nerve itself. The explanation of this is that the perineurium forms a barrier between the lymph spaces of the nerve and those of surrounding parts. If a nerve in a living animal be exposed, and the wound filled with water in which vermilion is suspended, then the leucocytes which accumulate take up the vermilion and carry it in various directions, but not into the nerve. But if a nerve in a suppurating wound be itself wounded so as to lay open its internal structure, then suppuration will readily extend into it.

An exception to this condition is afforded by the nerves before their exit from the skull or spinal canal. These are much less protected by an external sheath, and in consequence acute inflammations, such as simple and tubercular leptomeningitis, readily involve the substance of those nerves.

ic **inflammations** also extend, by contiguity, to nerves. Thus nmation of a joint, or a dysenteric inflammation of the in- nay give rise to a neuritis. It is most frequent as a result **imation of the pelvic organs,**—the bladder, uterus, etc. It ant to observe that inflammations originating thus may extend ierves, and we may have an **Ascending neuritis** which may even to the spinal cord and its membranes. Probably the having obtained entrance, gradually finds its way along the aces of the nerve, which we have seen to be somewhat inde- of those around.

prous neuritis.—This is characterized by the specific leprous iation which occurs in the nerve-stems, as already described, lition being a specific interstitial neuritis with atrophy of e fibres and consequent sensory and motor phenomena (see 209).

philitic Neuritis.—This mostly occurs in the cranial nerves, gumma or gummatous inflammation of the meninges involves n its transit from the brain to its foramen.

nours of Nerves.—The term **Neuroma** is applied to almost of tumours in the course of nerves, and as the majority of not consist of nervous tissue, they are to be regarded as iromata. In the true neuromata there is new-formation of res which form a considerable portion of the tissue (see Figs. , p. 306). The false neuromata are mostly fibrous tumours of nd there are two forms which deserve special mention.

orm neuroma consists of a series of thickened cords composed ctive tissue in the midst of which the nerve fibres are con- The connective tissue may, to a considerable extent, take the s of mucous tissue.

le neuromata are really fibrous-tissue tumours, and as such ibed at p. 305.

na is very rare in nerves. **Cancers** do not occur as primary but nerves are often involved in the extension of such from neighbouring parts. It often happens that a cancer or grows around a nerve, which passes through its midst without the seat of the tumour tissue. This is again to be associated apparent independence of the lymph spaces in nerves. Some- wever, a cancer breaks into a nerve, and grows in the lymph etween the perineurium and the bundle of fibres. In such nerve fibres undergo degeneration.

ire.—RANVIER, Leçons sur l'histologie du système nerveux, 1878; CORNIL , Histol. path., latest edition; WOLBERG, Deutsch. Zeitschr. f. Chir.,

xviii. and xix., 1883 (with literature); **Pitres** et **Vaillard**, Arch. d. Phys., v., 1885; **Stroebe** (Degeneration and Regeneration), Ziegler's Beiträge, xiii., 1893; **Weir Mitchell**, Injuries of Nerves, 1872; **Weir Mitchell**, **Morehouse**, and **Keen**. Gunshot wounds and other injuries of nerves, 1881; **Leyden** (Ascending neuritis). Volkmann's Vorträge, Syd. Soc. transl., 1876; **Bowlby**, Injuries and Diseases of Nerves, 1889: **Kennedy** (Degeneration and Regeneration), Phil. Trans. of Roy. Soc., vol. clxxxviii., p. 257, 1897, and (historical with literature) Proceed. Phil. Soc. of Glasgow, 1897-98. *Trophoneuroses*—**Weir Mitchell** (Erythromelalgia), Amer. Journ. Med. Sciences, 1878; **Barlow**, Allbutt's Syst. of Med., vi., 1899; **Dercum** (Adiposis dolorosa), Twentieth Cent. Pract. of Med., xi., 1897; **Hale White**, Brit. Med. Journ., ii., 1899; **Allbutt**, Syst of Med., vi., 1899. *Multiple neuritis*—see full account by **Buzzard**, Harveian Lectures, in Lancet, 1885, vol. ii., also separate publication; **Drummond**, Peripheral paralysis, 1888; **Finlay**, Trans. Med. Chir. Soc., 1887; **Ross**, Med. Chronicle, 1890; **Ross** and **Bury**, On Peripheral neuritis, 1893. *Tumours*—see literature under Neuroma, pp. 329, 330.

B.—The Spinal Cord and Medulla Oblongata.

Anatomical Introduction.—The cord is made up of grey substance, forming the ganglionic centres and consisting of ganglion cells in the midst of a fine network, and of white substance consisting of medullated nerve fibres having essentially the structure of those in the peripheral nerves.

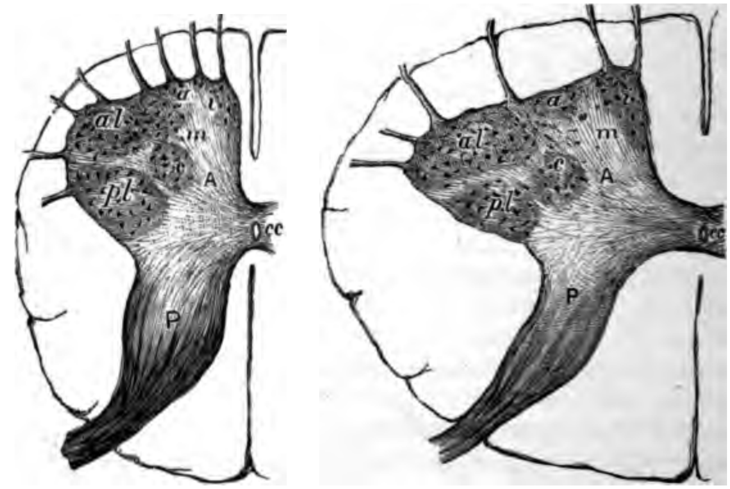


Fig. 447.—Sections of spinal cord from middle of lumbar and cervical enlargements, showing groups of ganglion cells; *al* and *pl*, antero-lateral and postero-lateral, *a*, anterior, *i*, internal, *c*, central, *m*, median, groups. (Ross.)

The grey substance of the cord is arranged in the well-known form of an anterior and a posterior cornu on either side, with a commissure across the middle line. The ganglionic centres have their seat chiefly in the anterior cornua, and form tolerably definite groups of cells whose arrangement may be followed by reference [illegible] shows sections of the lumbar and cervical enlargements. There [illegible] into antero-lateral and postero-lateral (*al* and *pl*), the up (*a*), and the internal group (*i*). Towards the centre of the horn is group (*c*). The median group (*m*) is much larger in the cervical than rts of the cord, and so causes the horn to be extended laterally (see **Lastly**, there is a group of cells, generally called Clarke's vesicular uated near the internal border of the posterior horns close to the mmissure. The group is present only in the lower part of the cervical t, in the dorsal region, and in the upper part of the lumbar enlargement . 448).

e **substance**, consisting of nerve fibres, forms connections in the first the various orders of centres in the cord itself, and in the second place gher centres above the cord, in We may thus distinguish two rve fibres, one forming con- thin the cord and medulla and rming communications between d the cerebellum and cerebrum. ets of fibres are divisible again t and efferent.

t of very peculiar interest, that s of fibres distinguished above developed not only separately rent periods, and so the aid of has been sought to enable us ish between them. The fibres ect the different parts of the edulla with each other may be the **Primary** or **Fundamental** it is found that they are the l, while those forming higher are of subsequent development, named **Secondary** or **Accessory** nerve fibres are first developed medullary sheath, and recently ts are therefore much paler than those which have acquired it, we a means of distinguishing the fundamental from the secondary. What be understood by reference to Fig. 449, which represents a transverse he cervical cord in the fœtus of nine months.

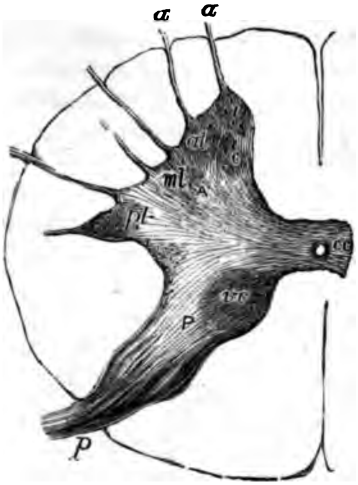


Fig. 448.—Section of dorsal region of cord. Letters same as in previous figure, with the addition that the antero-lateral and postero-lateral groups are separated by a medio-lateral area (*ml*), and Clarke's column (*vc*) is shown. (Ross).

developed fibres immediately surround the grey matter, and are called **and Posterior root-zones**, the latter being also sometimes called the Burdach. As they form communications between one part of the grey another, the fibres are comparatively short and their number is proportion to the amount of grey matter, or at least of ganglion horns. These fibres therefore do not diminish from above down- the others.

bres forming communications between the brain and cord, the best those which convey the motor impulses from the brain to the cord. the **Pyramidal tract**. We shall afterwards trace them from the cortex downwards, but at present we take them up at the medulla oblongata. form the anterior pyramids and most of the fibres decussate so that they occupy the opposite side to that which they have in the brain.

Some of them, however, do not decussate, but remain in the anterior parts of the cord, forming a small band on either side of the anterior longitudinal fissure,—the **Column of Türck** (T in figure). The great mass of the fibres, having decussated, pass to the lateral column of the cord, where they occupy a definite position in its posterior parts (*pt* in figure). The fibres in both these positions diminish in number from above downwards, as they pass into the grey substance of the cord at successive levels in order to come into relation with the centres in the anterior cornua.

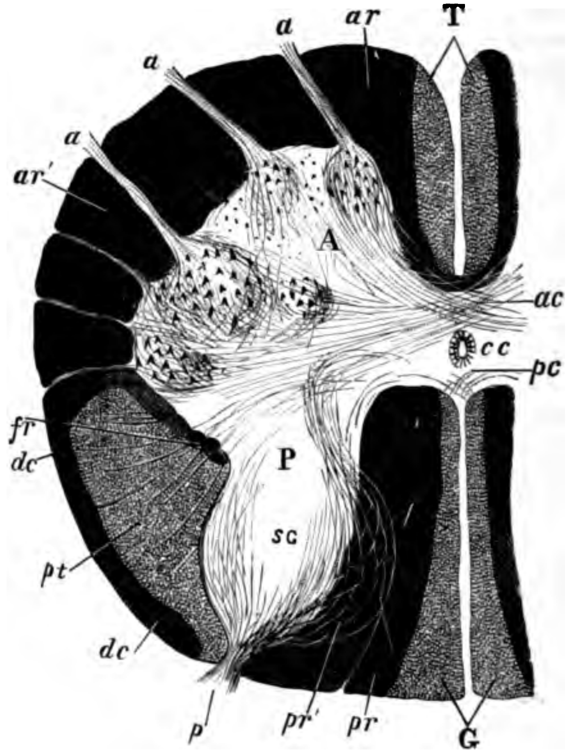


Fig. 449.—Cervical enlargement of cord in a fœtus of nine months. A and P, anterior and posterior cornua; G, columns of Goll; T, columns of Türck; *ar* and *pr*, anterior and posterior root-zones; *pt*, pyramidal tract; *dc*, direct cerebellar tract. (Ross.)

The secondary centripetal fibres, or those which form sensory connections between the cord and brain, are represented by a tract in the posterior columns lying next the posterior longitudinal fissure, and occupying a position somewhat similar to that of the columns of Türck anteriorly. These are called the **Columns of Goll** (G in figure).

Besides this there is a tract which forms communications between the cerebellum and the cord, but which is not of late development. This is the so-called **Direct cerebellar tract** (*dc* in figure), which lies in the lateral column outside the pyramidal tract, and as if flattened against the surface. The function of this tract is *not* known, but it is composed of centripetal fibres and diminishes from above downwards even more quickly than the pyramidal tract, so that by its disappearance the latter may come to the surface.

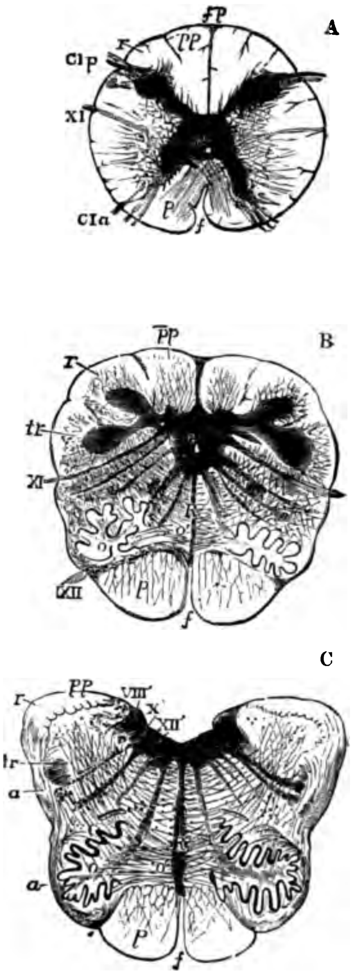


Fig. 450.—Medulla oblongata at various levels, A, at decussation of pyramids (*p*), the general shape of the cornua still retained. B, higher up, the grey matter passing backwards, and pyramids becoming more isolated. C, in fourth ventricle, the nuclei in the floor of which are shown. (Quain.)

According to Gowers there is a centripetal tract anterior to the direct cerebellar and pyramidal tracts, and lying for the most part close to the surface of the cord where it extends almost to the anterior median fissure. This is called the **Antero-lateral ascending tract** or **Column of Gowers**. It is thus similar in position to the cerebellar tract.

In the **Medulla oblongata** the grey and white substances of the cord may be traced upwards, but they undergo considerable dislocation. From the examination of Fig. 450 it will be seen that, as the central canal passes backwards and finally opens out in the fourth ventricle, the grey matter departing from its arrangement into cornua but still aggregated in the neighbourhood of the central canal and ventricle, forms various masses in the posterior part of the medulla.

These masses have special importance as being the nuclei of origin of certain nerves, and will be afterwards more particularly referred to, in connection with bulbar paralysis. The white substance gradually comes to occupy the middle and anterior parts of the medulla, and the olivary body is intercalated in its midst. The pyramidal tract is easily recognized here, forming the anterior pyramids (*p*), which decussate at the lower part of the medulla (A). The motor fibres, having assumed a position in front, remain anterior to the sensory in the rest of their course in the brain.

Post-mortem changes and injuries. Artefacts.—The soft structures of the cord and brain are very liable to injury during the process of removal, and to distortions and other changes in the course of hardening. Great care should be exercised in removing the parts, and also in placing them into the hardening media in such a way as that they shall not be twisted or distorted. In spite of all precautions there are liable to be artificial changes in the tissue, especially when the post-mortem is made some time after death. These various changes and injuries constitute the so-called Artefacts. It is well to have the post-mortem examination made as soon as possible, and in the meantime the body may be placed with the face downwards and in a cold atmosphere. Recently a method of injecting formalin into the cranial cavity through the orbit has come into use. This has decided advantages both in rendering the brain and cord more easily handled without risk of injury and in preventing post-mortem changes.

Literature.—For a very full exposition of the structure and development of the cord see Ross's Nervous system, vol. i. An important contribution is that by Flechsig, Die Leitungsbahnen im Gehirn und Rückenmark des Menschen, 1876. For diseases of spinal cord, Ross and Gowers are very complete; also Erb's very excellent work in Ziemssen's Enclycopædia; Charcot, Lectures on dis. of nervous syst., New Syd. Soc. transl., 2nd series, 1877 and 1881. Bramwell, Dis. of spinal cord, 3rd ed., 1895; Hammond, A treatise on dis. of nervous system, 6th ed., 1876; Leyden, Klinik der Rückenmarkskrankheiten, 1875. Paul Blocq and Albert Londe, Anat. path de la moëlle épinière, Paris, 1891; Pierre Marie, Lect. on dis. of spinal cord, New Syd. Soc. transl., 1895; Van Gieson, Artefacts of the nervous system, reprint from New York Medical Journal, 1892.

I.—SECONDARY DEGENERATIONS IN THE CORD.

Causation.—Secondary degenerations occur in the brain and spinal cord as a result of interruption of nerve fibres. In principle they are similar to the degeneration of peripheral nerves after division of their fibres. The interruption to the nerve fibres may be in the brain, in the cord itself, or in the posterior nerve-roots. Those occurring in the brain are mostly the result of hæmorrhages, softenings, or other coarse lesions. In the cord itself interruption is the result of inflammation, of direct injuries, or of lesions which press on the cord. Acute curvature of the spine, whether the result of injury, as when there occurs a fracture-dislocation of the vertebræ, or of disease, as in tuberculosis of the vertebræ, is a somewhat frequent cause. Pressure on the cord is produced in various ways. As the cord is within a rigid bony canal, any increase in the contents of the canal is apt to cause pressure on the cord. Thus hæmorrhage into the spinal canal, such as results from an aneurysm bursting into the canal, may cause it. Again tuberculosis of the vertebræ, if it extends to the membranes of the cord, leads to great thickening of them, a pulpy granulation tissue being produced like that in tuberculosis of joints. The pressure of this new-formed tissue has, in several cases observed by the author, led to interruption to the cord. Again, tumours of the membranes or of the cord may have a similar result. Syphilitic lesions in some cases press on the cord and lead to interruption. Lastly, inflammations in the cord itself, by the pressure of the exudation or, in chronic inflammation, of the new-formed connective tissue may interrupt the nerve fibres.

haracter of the changes. Grey Degeneration. Sclerosis.—We e already seen that when a nerve stem in an animal or in man is ded, the peripheral portion of the nerve degenerates. The most minent changes are in the medullary sheath which coagulates, then aks up, and is finally absorbed. The degeneration occurs from the nt of section towards the periphery, and we have seen that the lanation of this seems to be that the nerve fibres are cut off from nerve cells of which the axis cylinders are prolongations. In the tral nervous system, when the fibres are interrupted, the degenera- ı is of the same character as in peripheral nerves, and results in the truction of the medullary sheath.

The opaque dead white colour of the white or fibrous nerve sub- nce is due to the medullary sheath, which is a highly refracting

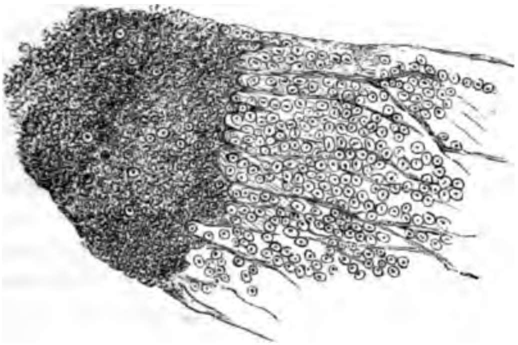


Fig. 451.—Sclerosis or grey degeneration of cord. To the right is normal white substance. To the left the degenerated tissue shows a granular basis-substance in which a few nerve fibres are still visible. From a case of descending degeneration. × 80.

y substance. If this medullary sheath be lost, then the white ve substance becomes grey, and so we speak of Grey degenera- ı in all cases where the medullary sheath is lost, whether from cause we are considering or not. A tract of white nervous ue affected with this degeneration will be like a tract of grey stance.

When a degenerated area is examined under the microscope the st marked change is the great reduction in the number of nerve es, as shown in Fig. 451. The connective substance is greatly eased, and the nerve fibres appear only at intervals, a few sur- ing in the midst of the general destruction. There is sometimes o considerable shrinking of the degenerated area, but this is ch more manifest in the medulla oblongata and parts above it n in the cord.

In addition to simple degeneration there is sometimes a new-formation of connective tissue, which some regard as inflammatory in character. The inflammatory character is little marked in secondary degeneration, but there are some forms of grey degeneration in which the inflammatory new-formation is perhaps the primary factor, and the degeneration of the nerve fibres the result of it. Whether there be new-formed connective tissue or not, and whether the process be inflammatory or not, the absence of the soft medullary sheath causes a hardening of the tissue, and so the term **Sclerosis** when applied to the white substance is nearly equivalent to grey degeneration.

It has been said above that the degeneration occurs in the fibres which are cut off from their cells, and it seems that in the cord as a rule the cells are at the lower termination of the afferent fibres and at the upper termination of the efferent. Hence the degeneration mostly follows the direction in which the nerve conducts, passing upwards from the seat of lesion in the case of centripetal fibres and downwards in the case of centrifugal. So we speak of ascending and descending degeneration.

The degeneration takes some time to develop. According to experiments in dogs it begins fourteen days after the infliction of an injury, but it is many weeks before the appearances are fully established.

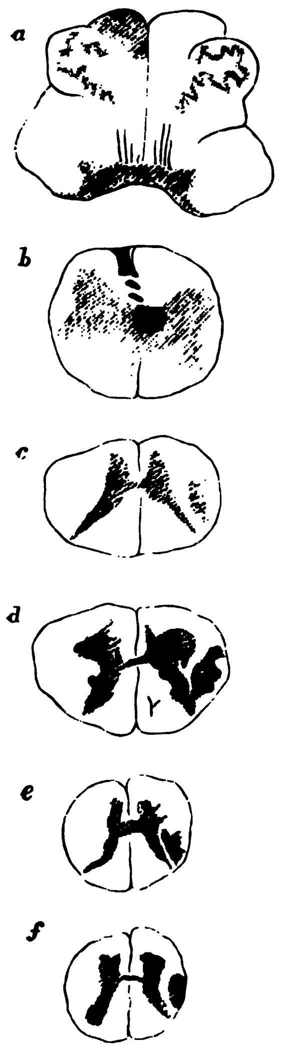


Fig. 452.—Descending degeneration in medulla oblongata and cord. *a*, Medulla at fourth ventricle, *b*, at decussation, *c*, *d*, *e*, *f*, cord in upper and lower cervical, dorsal, and lumbar regions.

FORMS OF SECONDARY DEGENERATION.

1. **Descending grey degeneration** (*Descending sclerosis*).—As we have just seen, this lesion affects centrifugal or motor fibres, including the fibres of the anterior root-zone and the pyramidal tract. The former are short fibres, and when they are interrupted

e is a descending degeneration extending only a short distance nwards. But the fibres of the pyramidal tract are continuous 1 the brain downwards to the extremity of the cord, and wher- · interrupted they show degeneration in all parts situated below lesion.

'he degeneration of the pyramidal tract is most frequently brought ut by a Lesion of the brain, and in that case it exists in the parts he tract above as well as in those below the medulla oblongata. have here to consider it in the medulla and cord. In the medulla ›ngata it occupies the anterior pyramid (see Fig 452 *a*), where it quently produces great shrinking. At the lower part of the medulla g. 452 *b*) the degenerated fibres decussate and the degeneration es up its position at first at the side of the central canal (see Fig.), afterwards, in the cord, passing into the lateral columns in the

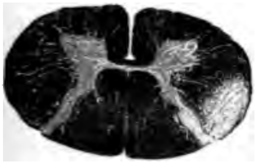


Fig. 453.—Descending degeneration. Cervical region. The pyramidal tract on the right side is pale.

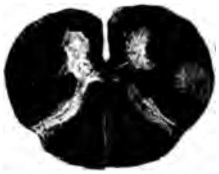


Fig. 454.—Descending degeneration. Lumbar region. The affected pyramidal tract small and reaching the surface.

gular position of the pyramidal tract (Fig. 452, *c*, *d*, *e*, *f*, and Figs. 3 and 454). In some cases it entirely decussates, but the column of irck in the anterior white column is also affected in most cases. In whole course the lesion diminishes from above downwards, but is aceable down to the lumbar region. The reason for this is that the ramidal tract gradually diminishes in bulk from above downwards account of its fibres leaving it from time to time to come into lation with the branching processes of the large motor cells in the terior horns. It may be noted also that, unlike what has been scribed as occurring on section or interruption of a spinal nerve, en the fibres of this tract suffer interruption or injury, degeneration urs *simultaneously* in the whole length of the fibre distal to the point interruption, and is only a descending degeneration in the sense that ccurs below the point of injury.

The pyramidal tract may be interrupted in any part of its course, l it may be so in the cord. If the entire cord be divided there is, mediately beneath the point of section, a degeneration of the anterior ›t-zones which is continued but a short distance. There is also a degeneration of the pyramidal tract on both sides continued downwards the whole length of the cord. The interruption either in the cord or brain may be incomplete, and in that case the degenerated fibres will be fewer in number and the area less distinctive in appearance.

Perhaps it should be mentioned that now and again in cases of unilateral cerebral lesion giving rise to descending degeneration in the pyramidal tracts, the degeneration is double, involving the tracts of both sides. The explanation of such anomalous cases must be found in irregularity in the distribution of the pyramidal fibres, but in all cases at least a few fibres may be found degenerated in the situation of the pyramidal tract of the same side (idio-lateral) as the lesion.

Effect on function of descending sclerosis.—We have already seen that the pyramidal fibres end in the cord at successive levels, passing into the ganglionic centres. When the fibres are degenerated these centres are cut off from the higher centres and left more to themselves. They are still connected with the muscles, which retain their contractile power. Voluntary motion is lost, but certain involuntary muscular phenomena may be even exaggerated.

Late rigidity as seen in hemiplegia where one side of the body is affected, or in paraplegia from injury to the cord where both sides are involved, comes on a considerable time after the onset of the paralysis, and may be regarded as coinciding in time with the full development of the sclerosis. There is here a more or less permanent contraction of some muscles with absence of contraction in others, producing sometimes fixation of the members of the body in special positions so as to have the appearance of deformity. This fixed condition, due to the muscular spasm, is often called **Contracture.** It implies a continuous impulse to the contracted muscles originating in the cord or elsewhere. Charcot suggests that the inflammatory process which he supposes to be involved in the sclerosis may irritate the fibres passing to the anterior cornua and so result in the stimulation of the muscular centres there. But this view can hardly be accepted; there may be almost no signs of inflammation in the affected part and yet marked rigidity. Besides, it is difficult to understand how irritation of degenerated and virtually lost fibres should cause stimulation of the ganglion cells. A more probable explanation is suggested by Hitzig. Taking as an example the case of the arm in hemiplegia, it appears that the contraction occurs most readily in those muscles which are in a position to contract most easily. The hemiplegic generally lies in bed with his forearm across his chest, and even when walking about he supports it across the chest, and it is the biceps which becomes rigid. Then it has been shown that when the fingers are released from the of the muscles and left to assume the position to which the and ligaments best accommodate themselves, they assume a lexed position, such as we see in the dead body. It is obvious he flexor muscles will most easily contract under these circum- s, and it is they which get rigid in hemiplegics. Take along this the fact which Volkmann points out, that muscles can ly contract but cannot actively relax, and it is seen that any impulse is apt to be cumulative when there is no action of onistic muscles. The centres of the anterior cornua are still in ction with the muscles, and although cut off from the upper brain ill exposed to irregular and, as it were, accidental stimulation. are reflex stimuli, and there are stimuli from above conveyed in ndabout way through the still open communications in the cord. ltitude of slight stimulations will reach the centres and as the result ummation of stimuli" feeble impulses will be conveyed to the es. Those which are stretched will not contract, but those which placed as to contract easily will do so, at first feebly but with lative force. This view is supported by the fact that, in the early of late rigidity, there is often considerable relaxation of the es after prolonged rest, as in sleep, so that a limb which was rigid ht is found in the morning soft and movable. The ganglion cells ep are protected from external stimulation and they cease acting. Marie, on the other hand, is inclined to the opinion that the y may be the result of the withdrawal of the inhibitory function pyramidal tracts upon the centres in the cord and hence their ed and unceasing action.

exaggerated **Muscle reflex** which is exemplified in the familiar l demonstration of the **Knee-jerk** and **Ankle-clonus**, may be led as due to the isolation of the muscular centres in the cord. the control of higher centres is removed, lower centres usually ore readily. The skin reflex is frequently decreased, but the e centres seem to be more powerfully acted on by stimuli coming he muscles.

Ascending grey degeneration (*Ascending sclerosis*).—This condi- ccurs as a result of any cause which interrupts the ascending or y fibres of the cord. The degeneration affects the centripetal and these we have already seen to be of two kinds. There are ort fibres communicating between different segments of the cord, rming the posterior root-zones, and there are the longer fibres unicating between the cord and brain, and forming the columns ll, the direct cerebellar, and partly the antero-lateral tracts. diately above the lesion, all these are affected, so that the degeneration has considerable lateral extension, involving the whole of the posterior columns and the direct cerebellar tracts. But the lesion soon limits itself to the columns of Goll, the direct cerebellar, and partly the antero-lateral tracts (see Figs. 455 and 456), and in those parts it can be traced up to the restiform body on the one hand, and the cerebellum on the other. According to Schiefferdecker, the degeneration in these situations diminishes from below upwards, the diminution occurring at intervals as if, at definite levels, fibres passed into the grey matter of the cord.

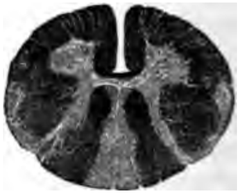


Fig. 456.—Ascending grey degeneration. The columns of Goll and direct cerebellar tracts are visibly pale.

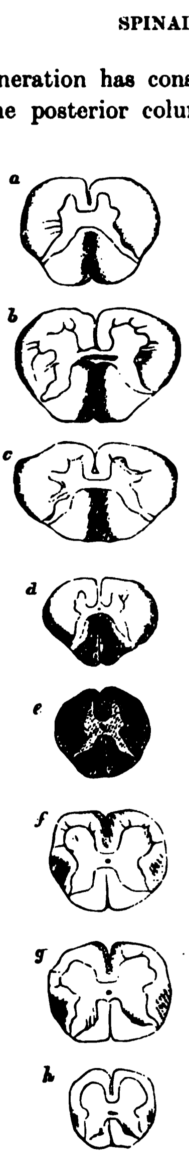


Fig. 455.—Transverse myelitis (*c*) with secondary ascending and descending degeneration. At *d* the ascending degeneration affects the posterior root-zones, the columns of Goll, and the direct cerebellar tracts, but above that it is confined to the two latter. At *f* to *h*, the columns of Türck and the pyramidal tracts are affected. (Erb.)

Some cases have been recorded in which a tumour pressing on the cauda equina, or a severe traumatic lesion of the sciatic nerves, had led to ascending degeneration of the cord. In the lumbar and lower dorsal regions the whole posterior white columns were degenerated, but on passing upwards the degeneration became limited to the columns of Goll and the cerebellar fibres as above. We may infer from this that the fibres of the posterior column are, to a large extent, continuous with the posterior nerve-roots, and that they are prolongations (axons) of the cells in the ganglia of the posterior roots outside the cord.

It will be evident that a lesion which interrupts the cord will lead to an ascending degeneration above its seat and a descending degeneration below it, as in Fig. 455. The degeneration will diminish in both cases as we pass from the lesion, quickly at first, but afterwards more gradually.

3. **Degeneration in the cord after amputations.**—The removal of a limb abolishes the function of the nervous structures concerned in the movements and other actions of the limb, and so these structures undergo atrophy from disuse. The posterior roots of the nerves are often slightly atrophied, but the white columns of the cord are not affected. The principal change is in the anterior cornua, where some of the ganglion cells completely disappear, and others are shorn of their processes and atrophied. This occurs at a part of the cord corresponding with the amputated limb, and on the same side of the body. If the amputation has been made comparatively late in life there is usually little change in the cord; the earlier the age of the person at the time of the amputation the more likely are these changes to occur.

In a case recorded by Edinger, in which intra-uterine amputation of the forearm had occurred, and the person lived to the age of 52, there was considerable atrophy of the nerves and of the corresponding half of the cord, especially of the grey matter. There was also some atrophy in the motor region of the convolutions in the brain.

Literature.—Besides general works already noted, CHARCOT, Lectures on localization of cerebral and spinal diseases, Syd. Soc. transl., 1883; TÜRCK, Sitzungsber. d. Akad. d. Wiss. Wien, vols. vi., 1851, and xi., 1853; LEYDEN, Deutsch. Klinik, 1863; GOWERS, Diagnosis of dis. of spinal cord, 2nd ed., 1881, and dis. of nervous system, latest edition; SCHIEFFERDECKER, Virch. Arch., lxvii., 1876; DRESCHFELD (Cord after amputation), Jour. of Anat. and Phys., 1879, xiv., 424; GENZMER, Virch. Arch., 1876, lxvi., 265; EDINGER, Virch. Arch., 1882, lxxxix., 46, and Vorlesungen über den Bau der nerv. Centralorgan.

II.—INFLAMMATIONS OF THE SPINAL CORD.

In its widest acceptation, inflammation of the spinal cord, or myelitis, includes a large number of widely different conditions each of which will be considered separately. The cases may for convenience be divided into two groups. In one of these the affection has a limited longitudinal extension, but involves the cord rather in its thickness. For cases of this class it is customary to use the expression **Transverse myelitis** in order to distinguish them from those in which a considerable length of cord is attacked, while the inflammation has a limited transverse extension. The former are usually due to a definite cause which acts on the cord at a particular level. In the second group the inflammation follows a particular physiological system in the cord, as for instance a tract of white substance, and extends in it for some distance from above downwards; hence the name **Systematic inflam-**

mations applied to this group. Such inflammations may involve the white substance or the grey substance, and they are often distinguished by the names **Leucomyelitis** (λευκός = white) and **Poliomyelitis** (πολιός = grey). These inflammations have for the most part no assignable cause, and are sometimes called spontaneous. In some of them the process shows, perhaps, more of a degenerative than an inflammatory character. Besides these there is a form of myelitis in which the lesions are somewhat irregularly diffused over different parts of the brain and cord.

A.—Transverse Myelitis.

1. **Acute transverse myelitis (Softening of the cord)—Causation.**—Cases occasionally occur of a limited transverse myelitis, manifested in a softening of the cord, without any sufficient cause being apparent. These cases, which are usually designated **spontaneous or primary,** are assigned to exposure to cold, especially when the body is overheated or during menstruation. The nature of the irritant in such cases, and its source, are quite obscure, as well as the reason for its localization at a particular part of the cord. Syphilis and certain of the acute specific fevers, such as small-pox, typhus fever, and measles, are sometimes assigned as causes of softening of the cord.

Direct injury to the cord, as by fractures and dislocations, and acute curvature of the spine, produce myelitis, especially where hæmorrhage has been induced. In this connection the great vascularity of the grey substance as compared with the white, is to be taken into account. An injury to the cord, as by an acute curvature or even a concussion, may produce a **hæmorrhage,** which is often limited to the grey substance. The hæmorrhage may itself be the efficient cause of the softening. Inflammations extending to the meninges may, by the action of the inflammatory exudation, induce a softening. Tumours have sometimes a similar effect, although their action is liable to be more gradual, so as to produce a chronic inflammation.

Characters of the lesion.—The myelitis is limited in longitudinal extent, and as the usual result is softening of the cord, the expression **Acute softening of the cord** is almost equivalent to myelitis. The softening is usually most manifest in the grey substance, and may even be apparently confined to it, but it involves the white substance as well, and usually the whole thickness of the cord.

The softened nervous tissue presents, in different cases, considerable variations in colour, so that red, yellow, grey, white, and even green softening have been described. If much blood has escaped from the vessels, there will be red softening merging into yellow.

The characteristic morbid changes are the breaking up of the nerve tissue and fatty degeneration of the other structures. In the white substance drops of myeline, which have escaped from the medullary sheath, are found, and the axis cylinders are swollen. The fatty degeneration is manifested by the presence of abundant compound granular corpuscles, which, to some extent, are probably leucocytes or neuroglia cells, which have picked up the disintegrated myeline; but there may be abundant leucocytes apart from these cells. There is also fatty degeneration of the walls of the blood-vessels, the fat here having a similar source.

The myelitis rarely goes on to suppuration, but usually passes into a chronic stage. The fat, both of the medullary sheath and of the compound granular corpuscles, is absorbed, and a condition of grey softening remains. As the inflammation becomes more chronic there is new-formation of connective tissue of a cicatricial character. In the midst of the connective tissue there are often to be found large cells with radiating processes, sometimes called "spider cells" or "Deiter's cells." These are very obscurely visible in the normal cord where they form part of the neuroglia, but here they are much enlarged. In this way the proper elements of the cord at the part affected may be replaced by a cicatrix or by a cyst, and its conduction interrupted. In some cases the interruption is not complete, and there may even be a partial regeneration of the conducting fibres, and a partial recovery from the paralysis.

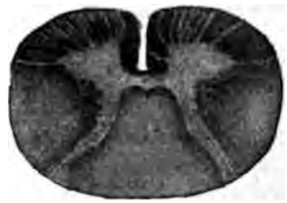


Fig. 457.—Extensive grey degeneration in the cord immediately above a transverse myelitis. The lesion affects the posterior and postero-lateral columns.

As a consequence of the lesion there is extensive sclerosis in the immediate neighbourhood, as shown in Fig. 457. This localizes itself above and below the seat of lesion as an ascending and descending grey degeneration of the usual distribution. There may be also an extension of the inflammation upwards in the pyramidal tract for a short distance from the seat of the lesion (as in the specimen figured).

Gowers has described an appearance as if a new-formation of nerve fibres were taking place, and certainly the fact that there may be a partial return of power after motor paralysis which has lasted twelve months, would seem to indicate that there may be some such new-formation.

2. **Chronic transverse myelitis.**—We have just seen that this condition may follow on an acute myelitis, but the inflammation may be chronic from the first, when it is produced by an irritant which acts gradually. It is most frequently the result of **Chronic compression of**

the cord, as in the case of curvature, or pressure by a tumour. It may also be propagated from the membranes, a spinal meningitis passing into a myelitis. We have already seen that it may arise by extension from a peripheral nerve, the inflammation travelling upwards to the cord. It occurs also from exposure to cold, from strains, etc., as in the case of acute myelitis.

The changes produced are those common to chronic inflammations. There is new-formation of a dense connective tissue, developing in the usual way from granulation tissue. The new-formed tissue causes compression of the proper nervous elements and their atrophy. In the white substance the nerve fibres disappear, and in the grey substance the ganglion cells. With the growth of this dense tissue there is an induration of the cord, and the term **Sclerosis** is applicable. In the white substance this is manifested by the usual appearance of grey degeneration. There is also a degree of shrinking of the parts, and this is often especially manifest in the grey substance.

As the nervous structures are partially or completely destroyed there is a greater or less interruption of the cord, and this results in the usual secondary degenerations above and below the seat of the lesion.

3. **Divers' paralysis. Caisson disease.**—Persons who have been working for considerable periods under a greatly increased atmospheric pressure, such as divers, or workers in caissons at the foundations of bridges or underground railways, sometimes in coming into the open air become paralyzed. It is usually a paralysis of the legs; but there may be apoplectic attacks with hemiplegia, indicating that the brain is affected, or there may be loss of consciousness with cyanosis and cardiac failure. The attack may be fatal, but recovery, especially if the patient is placed in an air-lock, usually takes place.

There seems little doubt that the condition arises from the abnormal escape of gas from the blood in the vessels. Under increased pressure a liquid dissolves more of a gas than under normal conditions, and in a person who has been under a pressure of two or three atmospheres more of the gases of the atmosphere are dissolved in the blood than under ordinary circumstances. When the individual returns to the ordinary atmospheric pressure, there is an excessive escape of gas, especially of nitrogen, which cannot be utilized by the tissues of the body and wide-spread air embolism results. In many cases the cord is affected. The cord being in a confined canal, pressure is exerted on the nerve tissue, and there may even be some tearing up of the tissue. There is rarely hæmorrhage. The injury to the cord may induce a subsequent inflammation, the spaces formed by the gases becoming occupied by round cells.

Literature.—Pott, Palsy from curvature of spine, 1776 and 1782; Brodie, Inries of the spine, 1837; Jaccoud, Des Paraplégies, 1864; Frommann, Normal und th. Anat. des Rückenmarks, 1867; Feinberg (Myelitis), Virch. Arch., lix., 1874; ell, Caisson disease, Lond., 1896; Bert, Paul, Comptes rend. Soc. de Biologie, 71-1873; Smith (literature), Allbutt's Syst. of Med., vii., 1899. For more comete literature see Ross, ii., 89.

B.—SYSTEMATIC MYELITIS AND DEGENERATION.

As already indicated, in the diseases included here the affection llows certain physiological systems, and we have, in the first place, inquire whether any explanation of this can be suggested.

General causation.—In almost all the examples of inflammation udied in other parts of this work, the extension of the process is ong definite paths. The irritant has been brought to an organ by e blood-vessels, or by some path of transit such as a mucous canal, d it has extended, it may be, by the lymphatics or along a surface. the lesions here to be considered, however, the problem is much ore difficult. The localization of the disease bears no relation to the lood-vessels or lymphatic vessels, and if the irritant is brought by the lood there must be local peculiarities leading to differences in the sceptibility of different structures.

In studying the various structures which constitute the cord we saw hat in the development of the cord a certain difference is apparent. In the white substance there are certain **Fundamental structures** constituting the root-zones, and certain **Accessory tracts** which are separately developed, and mostly of later formation. In the grey substance also there are differences in the periods at which the groups of anglion cells appear, so much so that some of them which appear later han the rest have been named **Accessory nuclei.** These are chiefly e median and medio-lateral groups. The various tracts of white bstance and groups of ganglion cells have apparently different powers resistance, and the more recently developed or accessory structures e less resistant. It is not unlikely indeed that in some cases these y be, from their origin, so unstable that without any obvious exciting se they may tend to degenerate. In this way the boundary line tween actual inflammations and simple degenerations is reached. here are some of the diseases here to be considered which have doubtedly the characters of inflammation, and even of acute inmmation. But there are others in which the characters are rather ose of a chronic degeneration or atrophy of the structures concerned, th very little of an inflammatory character.

There are thus various degrees of susceptibility in the different ructures of the cord and medulla oblongata, and when an irritant exists in the blood, developed perhaps in connection with exposure to cold or otherwise, there will be, according to circumstances, various manifestations.

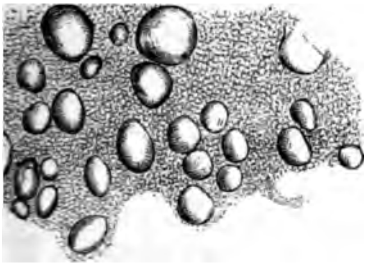
1. **Sclerosis of the posterior columns** (*Locomotor ataxia, Tabes dorsalis*).—**Causation.**—Syphilis is assigned as the cause of this disease in a large proportion of cases (according to Gowers in about two-thirds, and according to Erb even in larger proportion). Syphilis does not act by means of the local effects of a gumma or other inflammatory lesion. It seems rather that the disease is a remote effect of the syphilitic poison acting on a predisposed organ. In this respect it may perhaps be compared with amyloid degeneration, which is also a late result, on particular structures, of the syphilitic poison. The disease also occurs as a result of alcoholic excess, in which, again, the prolonged action of a poison is recognizable. Concussion of the spine, over-exertion, etc., have also been stated as causes.

Characters of the changes.—In connection with the causes assigned, the fact should be borne in mind that the lesions are largely degenerative, but that they also partake of the characters of chronic inflammation. They may be compared with those in peripheral neuritis, which is due to the action of similar poisonous agents.

If the cord is examined in well-advanced cases of this disease, the **Posterior white columns** are found grey and shrunken, and the posterior roots are also atrophied. There is often meningitis, the soft membranes being thickened and adherent to the cord beneath and sometimes to the dura mater on the surface. In early stages of the disease the changes in the cord may be invisible to the naked eye, but can be detected with the microscope. In advanced stages there may be similar changes in the cerebral nerves, *e.g.* the optic, the oculo-motor, the hypoglossal, etc.

The minute changes consist in atrophy of the nerve fibres and increase of the connective tissue, similar to that described as occurrin in secondary degenerations. As to the degree in which actual inflammatory processes exist opinions differ. The result is a sclerosis o the affected regions, and the tissue may have many amyloid bodies i it. These are round or oval bodies three or four times the size o blood-corpuscles and presenting a peculiar bright glancing appearanc (Fig. 458). They frequently present a concentric striation like grain of potato starch, and with iodine they take on a deep brown coloration These bodies are sometimes present in such numbers as to form th most prominent feature under the microscope.

The posterior columns are the parts affected, but the disease does no invade these columns uniformly. Its special seat is the outer parts o posterior columns, namely, **the Posterior root-zones,** or columns Burdach, and it is stated that these alone are affected in the earlier ges (see Fig. 459). **The Columns of Goll** are secondarily invaded, as result of an ascending sclerosis. That this is so appears from the ial examination of the cord at various levels. The disease begins, l is usually most advanced, in the lumbar region, but in the lowest t of that region the lateral parts of the posterior columns may be ie involved. On passing upwards the columns of Goll become also cted, so that in the upper half of the lumbar swelling the degenera- ı may be co-extensive with the posterior columns. This continues he dorsal region, but in the cervical the sclerosis begins to diminish ernally, and shades off into the columns of Goll, in which it may continued up into the restiform body. The actual primary lesion



g. 458.—Amyloid bodies from cord. ×300.

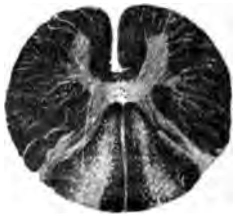


Fig. 459.—Cord in early stage of locomotor ataxia. The columns of Goll are unaffected, but the posterior root-zones are in a state of sclerosis.

herefore that in the external parts of the posterior columns, and affection in the columns of Goll is really an ascending secondary eneration, these columns being, as already stated, the principal of ascending sclerosis. It is to be noted, however, that the direct bellar tract and the antero-lateral tracts are not affected.

Besides extending to the columns of Goll. the disease commonly cts also the **Posterior roots,** which are often much atrophied. It y also extend to the **Posterior grey cornua,** in which case anæs- sia occurs, or to the **Lateral columns,** in which case paralysis ues; or it may even pass through to the **Anterior cornua,** when scular atrophy occurs in addition to paralysis. There is sometimes extension to the **Medulla oblongata,** as evidenced by inco-ordina- n of the muscles of the eyeball and of those of speech.

In a large proportion of cases the **Peripheral nerves** are affected ilarly to the posterior columns of the cord. There is atrophy the nerve fibres with increase of the connective tissue. It is the sensory nerves which are affected, and chiefly the fine filaments in the skin and joints, but probably the sensory fibres of the muscles also. The lesion diminishes on passing from the finer filaments to the larger stems. There are frequently similar changes in the Optic nerve and in the Ascending root of the fifth nerve.

Relation of lesion to function.—The lesion in the cord and nerves affects the sensory tracts, and yet the most prominent symptom is inco-ordination of motion. Violent pains are indeed commonly present at an early stage, and there is loss of sensation, more or less pronounced, when the disease is fully established. The inco-ordination is not a motor paralysis, but is due to interference with the centripetal nerve fibres, especially those which connect the muscles with the cord. The ganglia in the anterior cornua of the cord are, as we have seen, the immediate centres for the muscles, being centres of a low order dominated by higher ones. The centres are in relation with centripetal fibres and give off centrifugal ones, thus forming a complete nervous system of a low order. The centripetal fibres come to a large extent from the muscles, and keep the centres informed, so to speak, of the position and state of contraction of the muscles. Any break in the arc will set the whole apparatus at a disadvantage and interfere with the completeness of the action. Here there is a break in the centripetal system, probably more particularly in the fibres coming from the muscles, as evidenced by the very early loss of muscle reflex (according to Erb, whenever the ataxia is developed). In consequence the contractions of the muscles will be to some extent at random and without the accurate adjustment which exists normally. Probably also the normal tonicity of the muscles is, as Lockhart Clarke suggested, due to continuous stimulation of the ganglia in the cord by stimuli conveyed from the periphery. The interruption of the centripetal fibres will interfere with this stimulation, and the contraction of the muscles will start at a disadvantage. The absence of the knowledge of the state of the muscles which is implied in a break in the reflex arc may be partly compensated by using the eyes to direct the movements, the motor centres in the cord being, as it were, informe from above of the state of the muscles. The occurrence of tra paralysis indicates that the neighbouring motor tracts in the later columns have become involved.

Until recently such were the views generally current among neuro-pathologist but our conceptions of the disease have undergone essential change, and we are longer inclined to look upon tabes as a *primary* sclerosis of the posterior column but rather to think of this as consecutive to changes elsewhere,—in the posteri *roots* or rather in their ganglia. As has already been pointed out, the posteri lumns must be considered as made up in great part of the *axons* or axis cylinder ocesses of the cells of the ganglia of the posterior roots, and that the sensory res in the peripheral nerves represent their protoplasmic processes or dendrons, d hence both own as their trophic or nutritive centres the cells of those ganglia. long as these fibres are in organic association with their trophic centres, and ey in turn are in a normal condition, then the nutrition of both sets of fibres is altered; but should the nutrition of the ganglion cells suffer alteration, then generative changes follow in those fibres which go to form the posterior rve roots and the posterior columns of the cord; such degeneration being rely consecutive or sequential and *not* a primary degeneration, the changes the sensory fibres of the peripheral nerves must be regarded as a conquence of the alterations in their trophic centres in the ganglia of the posterior ots. In support of such a view there is, so far, not a great body of anatomical oof, but it is to be remembered that it is anything but the habit to examine these nglia in cases coming to a post-mortem examination, and besides, the detecn of slight changes either in them or in the nerves is difficult and uncerin. Still, such changes have been observed and figured by Oppenheim; and binski, according to Marie, in the year 1891, expressed the opinion that the gin of the degeneration of the posterior root fibres, and their continuation in posterior columns of the cord, was to be sought in a "functional derangement" the trophic centres in these ganglia. Marie, while not accepting such an lanation as representing the whole of the mechanism of the degenerative process tabes is, however, satisfied that changes do occur in the spinal ganglia in all es, and that these changes are of the greatest importance as regards the origin such degenerations. He is also inclined to think that these same changes lain, in part at least, the occurrence of the degenerations in the peripheral rves in this disease. Marie, further, is of opinion that there exist what he terms ipheral or terminal ganglion cells—cells which in the process of development ve become separated from the neural plates and carried along with the centrial developing organs, skin, muscles, tendons,—from which certain of the sensory res are developed, and which find their way through the ganglia and go to form rt of the posterior nerve roots and posterior columns of the cord. Thus, accordg to him, the nerve fibres of the posterior roots come from two distinct genetic d trophic centres, one in the cells of the corresponding spinal ganglia and the her in those peripheral ganglionic cells.

The changes in the posterior roots are, in any case, a prominent feature in ses of tabes, and have long been recognized; and, since the disease usually nifests itself first and chiefly in the legs, it is in the roots of the cauda uina and those of the lumbar portion of the cord that these changes are most nifest.

Trophic lesions.—In addition to the conditions already referred to, arcot has called special attention to certain trophic lesions which casionally occur in locomotor ataxia. These are of three kinds, mely, certain cutaneous eruptions, muscular atrophy, and affections the joints.

The **Cutaneous eruptions** occur in the earlier periods, usually coinding with the attacks of lightning pains, and they are in the form of cal eruptions of herpes, lichen and pemphigus.

Muscular atrophy is not very common in locomotor ataxia, and is of late occurrence. The muscles may waste as a direct result of paralysis—a slow atrophy from disuse. In some cases, however, there are localized atrophies of special muscles similar to those in progressive muscular atrophy and in bulbar paralysis. In these cases the disease has extended to the anterior cornua in which the cells, of which the nerve fibres are prolongations, are situated, and which in consequence have become destroyed.

The **Affections of the joints** consist in comparatively acute swellings, with exudation, followed by atrophy of the ends of the bones. Dislocations of the joints may occur in consequence. These trophic disturbances of the joints seem, like those of the muscles, to occur in cases where the disease extends to the anterior cornua, the whole organs of locomotion being apparently affected by the degeneration of the motor nerve centres. The propagation of the disease to the anterior cornua, leading to muscular atrophy or trophic affections of the joints, seems to be not uncommon, and may occur at a comparatively early period. This can hardly be regarded as remarkable when we consider that there are, for purposes of reflex action, direct connections between the posterior root-zones and the anterior cornua.

General paralysis of the insane is often complicated with ataxia, and the spinal cord presents sclerosis of the posterior columns similar to that in ordinary ataxia.

Friedreich's hereditary ataxia.—A considerable number of cases have been described in which motor inco-ordination has appeared at an early age in several members of the same family. There is, in these cases, probably a congenital faulty development of the cord, and the ataxia is the consequence rather of a degenerative than of an inflammatory process.

The lesion is not confined to the posterior columns, but affects also the lateral columns, involving usually the pyramidal and the direct cerebellar tracts, and sometimes extending forward at the periphery of the cord. There seems little tendency to extension to the grey matter, and hence proper paralysis and muscular atrophy as well as anæsthesia are uncommon. There is seldom any evidence of irritation in the sensory fibres such as we have in ordinary ataxia, evidenced by the lightning pains.

The sclerosis of the posterior columns is similar to that in tabes, and as in that condition the posterior nerve roots are also implicated. According to Gowers the degeneration of the lateral columns always involves the pyramidal fibres; but Marie, although admitting that the lesion occupies the position of the lateral columns, disputes that it is the ssed pyramidal fibres which are actually implicated in the change. e direct cerebellar tract and Gower's tract are also involved.

The disease frequently extends upwards to the medulla oblongata, evidenced by the occurrence of disturbance of speech and nystagmus. rophy of the cerebellum, pons, and olivary body have been described one case.

2. **Spontaneous or primary lateral sclerosis** (*Erb's Spastic paralysis*).— AML

1875 Erb described a condition characterized clinically by paresis d spasm or rigidity in the inferior extremities, without loss or pairment of sensation, and expressed the opinion that this depended a primary degenerative change in the pyramidal fibres of the lateral lumns of the cord. Since then this condition has been very frequently served clinically, and has been the subject of much discussion. For a ıg time no indubitable anatomical evidence was forthcoming in sup- rt of the view advanced by Erb, and indeed, even now if we were to nfine ourselves to such cases occurring in the adult, the anatomical idence is exceedingly meagre, nor has an absolutely conclusive demon- ation of the condition been furnished. Still a case published by eschfeld in 1881 and another by Strümpell in 1894 almost satisfy conditions. Although not infrequently observed clinically it is only ely that such cases come to post-mortem examination, since the ease does not tend much to shorten life; and for long such autopsies were obtained where the diagnosis of this condition had been made ring life, gave no confirmation of its separate existence, but merely owed this condition to be part of, it might be, a disseminated sclerosis a secondary degenerative change in the course of some form of yelitis. Westphal and some others have found a state of things which most satisfies the conditions in some cases of paretic dementia.

The symptoms already referred to as characteristic of descending lerosis are here very pronounced, namely, spasm of the muscles, iefly of the lower extremities, with exaggerated tendon reflex. here is also, of course, paralysis.

The sclerosis is alleged to be primary or spontaneous and implicates th pyramidal tracts, having thus a distribution like that in the scending degenerations already described; but here it usually begins the lumbar region of the cord, and both lateral tracts are simul- neously attacked. Occasionally there is an associated degeneration the cells of the anterior cornua, and in that case there is muscular rophy in addition to the other phenomena. To conditions of this nd, Charcot has given the name **Amyotrophic lateral sclerosis**.

3. **Postero-lateral sclerosis** (*Ataxic paraplegia*).—Clinically cases cur which present a combination of paraplegic weakness with spasm

and ataxy, and in which the pathological findings are a combined sclerosis of the lateral and posterior columns of the cord. The extent of the degeneration is, however, subject to a good deal of variation, and the clinical characters are also subject to considerable variety, so that a given case may exhibit signs closely allied to either spastic paraplegia or locomotor ataxy; still in the great majority of cases the condition is sufficiently distinctive clinically to be easily recognized. The sclerosis in the posterior columns differs, however, from that in tabes, in that it is usually less marked in the lumbar region than in the dorsal, and it has not its location specially in the root-zones of the postero-external columns. The degeneration in the lateral columns may also extend at times beyond the pyramidal tract and occasionally even the direct cerebellar tract may be invaded.

4. **Acute ascending paralysis** (*Landry's paralysis*).—In this disease there is a rapidly extending paralysis, commencing in the legs, extending to the trunk and arms, and usually causing death in a few days. It is however not always fatal. The pathological findings in this disease have been very various. Sometimes the most exhaustive and skilled examination has failed to discover any changes either in the peripheral or central nervous system or in the muscles, while in others vascular engorgement and exudation of leucocytes have been found around the vessels in the spinal cord; and recently MM. Pierre Marie and Marinesco (1895) have found softening of the grey substance of the anterior horns in the lumbar region, with great infiltration of leucocytes round the vessels, the walls of which ~~were also infiltrated~~. In the posterior horns what was practically the same condition was noted. By Nissl's method of staining, the ganglion cells which remained in the ventral cornua were found to be swollen, their contour was indistinct and there were changes in the chromatic substance. Cultures obtained from various parts of the central nervous system indicated the presence of microbes, some of which had resemblances to the bacillus of splenic fever; others were probably streptococci. The nerves showed no change. Bailey and Ewing (1896) also report capillary hæmorrhages and circumvascular infiltration in the grey substance of the cord and changes in the ganglion cells, but they failed to obtain any results from culture experiments. Other observers have reported changes, both parenchymatous and interstitial, in the peripheral nerves. The spleen, the mesenteric glands, and the closed follicles of the intestines have been found enlarged. All the facts seem to point to the disease being the result of some toxin which has an elective affinity for the motor neurons of the spinal cord, sometimes exerting its harmful influence on the cells themselves more particularly, at other

mes influencing mainly their prolongations in the peripheral nerves, ut what the agent producing the toxin is, is at present undetermined. oss and others regard the disease as a form of peripheral neuritis.

5. **Poliomyelitis anterior acuta** (*Infantile Paralysis, Acute Atrophic pinal Paralysis*).—**Causation.**—The features of this disease at the nset are those of an acute inflammation accompanied by marked eneral disturbance of health. These suggest a morbid poison acting n the body generally but selecting, as such agents do, a special locality r its action. Nothing is known as to the nature of the agent. The ct may be noted that the disease is much more frequent in the hotter onths of the year than in the others, and it is known to occur ccasionally in epidemic form. Medin expresses the belief that it is ue to some infection, at present undetermined, capable of communiation from person to person, although he holds that such a mode of nfection is most unusual. It is a disease mostly of children, although ot unknown in the adult.

The disease is an acute inflammation of the grey substance of the nterior cornua of the cord. In a case observed by Drummond where child died after a few hours' illness, there was redness of the anterior ornua, with minute extravasations, swelling of the ganglion cells, etc. n later cases, but still comparatively early, the anterior cornua are seen nder the microscope to be altered, not continuously, but in patches. hey contain numerous round cells and compound granular corpuscles. he ganglion cells in certain of the groups have disappeared or have hrunk considerably. At the periphery of the affected patches round ells are aggregated, and there is already some shrinking of the patches. he condition is most manifest in the lumbar and cervical enlargements. he anterior roots are also somewhat atrophied, and show evidences of egenerative changes.

Many cases have been examined years after the onset of the disease, t intervals varying from seventeen to sixty-one years, and the changes n the affected parts have been very obvious even to the naked eye. hese consist of sclerosis with shrinking, mainly of the anterior grey ornua, but also of the anterior and antero-lateral columns of white ubstance (see Fig. 460). These changes are very manifest when the ord has been hardened and fine transverse sections made. The hrinking of the horn affects certain of the groups of cells specially, nd the shrunken part consists largely of connective tissue in which here are visible no ganglion cells or only deformed and pigmented nes. Connective tissue with abundant nuclei and enormous numbers f amyloid bodies are visible. The lesion in the anterior cornua is by o means homogeneous or symmetrical. One cornu may be atrophied and the other normal, and on examining sections at different levels there is great variety in the longitudinal distribution. The anterior roots are also atrophied at the parts corresponding to the most affected portions of the cord, and they may appear to the naked eye small and grey.

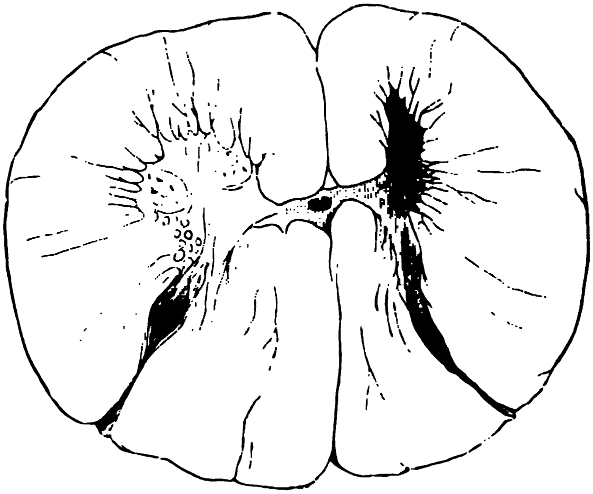


Fig. 460.—Anterior poliomyelitis. The right anterior cornu in the cervical region is shrunken, and there is atrophy of all the white columns on that side. From a woman, aged 50, who was the subject of infantile paralysis of the right arm. (CHARCOT.)

The disease usually begins acutely, and the paralysis generally assumes its full development almost at once. This extensive paralysis seems due in part to pressure by the distended vessels and inflammatory exudation, and in some cases by extravasated blood. In this period some ganglion cells may be destroyed, but those not absolutely destroyed may recover as the acute inflammation passes off. In many parts the inflammation is slight, and subsides completely; in others it is severe and goes on to sclerosis, and there is permanent destruction of the ganglion cells. Hence it is that a paralysis which has been at firs almost universal may be recovered from almost completely. Th improvement goes on till all the cells which are capable of it hav recovered, and there is a residue which have been permanently lost an cannot be restored. These permanently lost cells represent sing muscles and groups of muscles, and there is a corresponding localiz paralysis.

Trophic changes in muscles, etc.—The centres which have the dire control of the contractions of the individual muscles are probably t centres which command the nutrition of the muscles and their nerve r the permanently paralyzed muscles soon undergo a marked and pid atrophy, and the fibres of the anterior roots also degenerate. e muscular atrophy is not simply from disuse, for it is much greater d more rapid than in cases of paralysis where the anterior cornua are t affected. The muscles rapidly get soft and emaciated. Besides the s of substance there may be proliferation of the nuclei of the inter- tial connective tissue, and an increase in this tissue; sometimes there infiltration of fat in the interstitial tissue, so that the muscle may pear less atrophied than it in reality is. The defective development the bones and joints met with may be partly from disuse, but also bably to some extent from destruction of trophic centres. The nes of the paralyzed part do not grow normally, and the articulations imperfectly adjusted. Certain deformities ensue, the commonest d most prominent of which is club-foot. Curvature of the spine is o a comparatively frequent result. All through the disease the ient may maintain good general health, and after recovery from the tial fever he may present nothing abnormal but the paralysis and ophy. Through time he learns to use his remaining muscles to the t advantage, and may pass through a long life maimed by the infan- e attack.

Although most common in children a good many cases of this ease have now been recorded in **Adults**. Here also it is ushered by acute symptoms such as fever, pain in back and extremities, miting, headache. The paralysis develops mostly in a few hours, t it may be as late as a day or two. After a time recovery begins, d is more frequently complete than in the case of children. It is quently incomplete, and then we have paralytic deformities, which, wever, as the bones are fully formed, are not so striking as in the se of children. Here, also, there is rapid atrophy of the muscles, hich is not so liable to be concealed by fatty infiltration as in the case children.

6. **Poliomyelitis anterior subacuta.**—This disease is a rare one, and, the symptoms closely resemble those of multiple neuritis, the dis- mination of cases is not easy. The principal feature is the occurrence, th little or no disturbance of the general health, of a motor paralysis, tending, in the course of a few days or weeks, to the entire lower bs and then rapidly to the upper. It rarely takes the opposite urse. The muscles become slack and soft and lose their reflex itability, and they rapidly atrophy. There have been few post- ortem examinations, but they seem to show a chronic inflammation sclerosis of the anterior cornua with loss of the ganglion cells. The sease is frequently recovered from, but recovery is slow, and complete

restitution may take years. On the other hand, the disease may extend upwards and produce death.

7. **Poliomyelitis anterior chronica. Progressive muscular atrophy.**—In its clinical aspects the main feature is a gradually progressive atrophy and consequent paralysis of the muscles. It very commonly begins in the muscles of the hand, but progresses from one muscle to another till the death of the patient. In its later stages it frequently becomes associated with a corresponding form of disease of the medulla oblongata, namely, bulbar paralysis, to be considered next.

In the muscles the change consists in what may be regarded as a chronic inflammation. The muscle-nuclei increase in number, and as the contractile substance diminishes, the sarcolemma may come to be filled with cells, the result of this proliferation of the muscle-nuclei. At the same time the interstitial connective tissue shows active changes, increase of nuclei, and new-formation of connective tissue. In the muscular substance various forms of degeneration have been observed, chiefly fatty and hyaline or simple atrophy. In any case the muscular fibres are lost by degrees and the connective tissue increased, but not sufficiently to make up the bulk of the lost muscular substance. Sometimes a fatty infiltration of the connective tissue occurs, so that adipose tissue comes to occupy the place of the muscle to a large extent. This change, if it occurs, is only local, and pure atrophy may exist side by side with atrophy with formation of adipose tissue. This formation of adipose tissue is mostly a late, and by no means a characteristic, occurrence in this disease.

In the Spinal cord the essential changes are in the anterior cornua, but in most cases the pyramidal tracts are also involved. The lesion in the anterior cornua consists in a gradual atrophy of the large ganglion cells, affecting the parts corresponding with the atrophied muscles. These cells may have entirely disappeared or there may remain only small angular bodies representing them. There is at the same time an increase of the connective tissue, so that there is little change in the size or shape of the cornu.

According to Ross, the central grey column (the grey substance on either side the central canal) is most affected, being traversed by large canals and fibrillat In the annexed figure (Fig. 461) it is seen that the cells of the median group h also entirely disappeared, while the other groups of the anterior cornua are limit in size, the peripheral cells of the groups having disappeared, leaving only the m certain ones. It very commonly happens that, short of absolute destruction of t ganglion cells, they are greatly atrophied and pigmented (*pigmentary atrophy*).

The Pyramidal tracts, both those in the lateral and those in t anterior columns, are affected probably in all cases (Gowers), and t as been traced up through the medulla oblongata, pons, peduncles, capsule, and corona radiata to the motor convolutions of the where the large ganglion cells have been observed to be d.

Anterior nerve-roots are also atrophied. The nerve fibres may lmost entirely disappeared, nerves may be almost re- by connective tissue. The ation exists throughout the ral distribution of these and the terminal fibres in ophied muscles are greatly

n has recorded a case of progres- cular atrophy in which there was liar condition of the cord desig- ringomyelia. (See further on.)

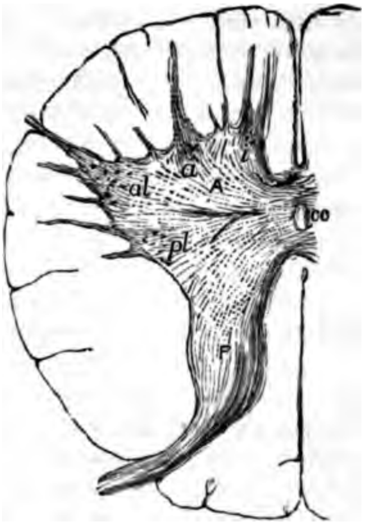


Fig. 461.—Progressive muscular atrophy—section of cord in cervical region, from an advanced case. The central portion of grey substance is fibrillated; the median group of cells has disappeared, and the other groups are atrophied. (Ross.)

tion of lesion to function.— disease we have a degenera- chronic inflammation affect- motor system, chiefly in its arts; in other words, there eneration of the spinal motor . The disease centres in nglion cells of the anterior but it affects the nerve rising from these, which are prolongations of their processes, and in most cases also the pyra- racts above them. The degeneration of the pyramidal tracts to be regarded as in any sense secondary, but as part of the ed lesion of the motor system. Indeed the order in which the t parts are involved varies somewhat, and we may have the dal tracts, at least in some parts of their course, affected in e of the anterior cornua, although this is not common. We ready seen that spasm of the muscles is the characteristic result neration of the pyramidal tracts, but this can only occur when erior cornua are unaffected. Hence in this disease rigidity of scles is not common, although in some cases it does occur locally, lly in the legs. Charcot has endeavoured to group this class s separately on the supposition that in them the lesion has in the pyramidal tracts, but it is doubtful whether this is a nt basis of distinction. In this latter class spastic paralysis precedes the wasting, and Charcot, as we have seen, has applied the designation Amyotrophic lateral sclerosis to such cases.

But in most cases the anterior cornua are affected before or simultaneously with the pyramidal tracts, hence there will usually be no evidence during life of the affection of the latter.

8. **Bulbar paralysis or Glosso-labio-laryngeal paralysis.**—This condition is called bulbar paralysis from the fact that the part affected is the medulla oblongata, which is frequently designated the bulb. There is progressive atrophy and paralysis of muscles supplied from the medulla oblongata. The muscles are mainly those of the tongue, lips, arches of palate, pharynx, and larynx, and in consequence there is progressive interference with articulation, chewing, swallowing, and even with the production of the voice. The disease may pass on later to affect the more vital functions of the medulla oblongata, *e.g.* those concerned in respiration, etc.

We have already seen in connection with the normal structure of the medulla oblongata that, on passing from the cord, the grey substance is dislocated backwards, and that in the posterior region of the medulla a set of grey nuclei appear, which, as the spinal canal opens up in the fourth ventricle, present themselves in the floor of that ventricle. These nuclei are mainly motor, corresponding with the anterior cornua, and they form the immediate centres for cerebral nerves (see Fig. 462). In the lower half of the fourth ventricle we find the hypoglossal nucleus (xii') occupying the part next the middle line. Outside it there is the spinal accessory nucleus which begins in the cord, and does not extend far up in the floor of the ventricle; it is not shown in the figure, but gives place to the nucleus of the pneumogastric or vagus (x'). Outside the vagus appears the glosso-pharyngeal, which partially divides the vagus nucleus into two. As we pass upwards the vagus nucleus becomes smaller and the hypoglossal and glosso-pharyngeal approximate to each other. Above that again come in the nucleus of the sixth (the abducens) in the middle line, and outside that the motor nucleus of the fifth and that of the facial. Outside these again are sensory nuclei, those of the acoustic and of the fifth.

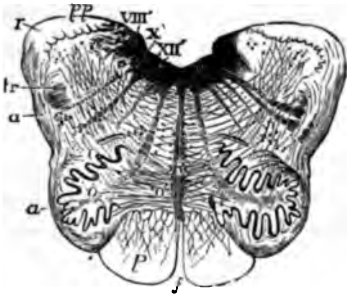


Fig. 462.—Medulla oblongata at the level of the fourth ventricle, showing the position of the grey nuclei. (QUAIN.)

In bulbar paralysis there is atrophy of these grey nuclei. It is *seldom* that opportunity is afforded of examining the medulla in recent ages, but according to Benedikt, who had such an opportunity, there e definite signs of inflammation—hyperæmia, thickening of the walls the vessels, and numerous round cells. In later periods increase of e connective tissue, with round cells and amyloid bodies, have been served. These changes centre in the nucleus of the hypoglossal, and is nucleus is usually most seriously damaged, but they pass soon to e accessory and vagus, while the glosso-pharyngeal sometimes, but t usually, escapes. The nucleus of the facial is often attacked, and metimes that of the motor branch of the fifth. The disease seldom tends to the sixth nerve, and never attacks the sensory nuclei of the oustic and fifth nerves.

There is in many cases degeneration of the nerve fibres in the terior pyramids similar to that in the pyramidal tracts in progressive uscular atrophy. There is reason to believe that in some cases e lesion is supra-nuclear, that is, in the fibres which connect ese with the motor region of the cerebral cortex, or at least in e terminations of these fibres in the nuclei, so that the affection , in such cases, really one of the upper segment of the cerebro-spinal is, or of the upper motor neuron; in this latter case there is no ovious wasting of muscles, and the disease would be analogous to teral sclerosis of the cord rather than to progressive muscular atrophy.

The corresponding nerves usually show considerable atrophy, especially e hypoglossal, and next to it the spinal accessory, vagus, and glosso-aryngeal. In them may be found a fatty degeneration involving struction of the medullary sheath and subsequent overgrowth of nnective tissue. In this way the nerve-root may come to be almost thing but a connective-tissue strand.

In the affected muscles the change is exactly parallel to that in ogressive muscular atrophy, with which sooner or later this disease is frequently associated. There is increase of the muscle-nuclei and nnective tissue, with destruction of the proper contractile substance, d consequent atrophy of the muscle as a whole. Thus the tongue, latine arches, lips, pharynx, and larynx may have their muscles rkedly atrophied. Sometimes also the muscles of the neck, especially e trapezius (supplied by the spinal accessory), are affected. In some ses the atrophy is obscured, as in progressive muscular atrophy, by e interstitial tissue becoming adipose.

9. **Pseudo-bulbar paralysis.**—Perhaps it may be well to mention in is place a condition known by the above name, which, although longing rather to diseases of the brain, clinically presents features so osely allied to the ordinary forms of bulbar paralysis that it may best e considered here.

It is a "bulbar paralysis" of *cerebral* origin, or, in other words, there is paralysis of the lips, tongue, and larynx, parts which, as we have just seen, have their lower centres in the "bulb"; but unlike the last group, where these centres have suffered degenerative change, in this the lesion is a bilateral one affecting the centres for those parts in the cortex—the lower part of the ascending frontal convolution, or about the knee of the internal capsule. Although the lesion is usually a bilateral one, in several instances it has been unilateral.

10. **Pseudo-hypertrophic paralysis.**—The resemblance of this disease to progressive muscular atrophy strongly suggests that it is primarily due to a lesion in the spinal cord. But repeated examinations of the cord have shown no constant lesion there, and in most cases the anterior cornua have been found intact. The muscular nerves are also apparently unaffected, and the general opinion is now that it is a primary disease of the muscular system. It occurs mostly in childhood.

The disease is due to a local constitutional fault which, like most constitutional peculiarities, is hereditary. Its hereditary nature is shown by its occurrence, in many instances, in several members of the same family. There is not apparently an inheritance of the disease, but there seems to be some condition in the parents which leads to the development of the disease in the offspring. Considering the close relationship in function and even in nutrition between the nervous system and the muscles, as shown by the affections already described, it is perhaps justifiable to consider this disease along with those of the spinal cord.

In many forms of disease in which the muscles are disused or paralyzed there is an overgrowth of the interstitial connective tissue, sometimes with excessive development of fat. We have noted this in some of the affections considered above, and it occurs also when th muscles are disused by reason of fixation of joints, etc. (See unde Fatty Infiltration.)

In the present disease there is an apparently spontaneous atrophy the muscular substance with a new-formation of connective and adipos tissue between the muscular fibres. The new-formation, at least i some situations, usually more than compensates in bulk for the atrophy and there is an apparent hypertrophy of the muscle as a whole. By the time the patient dies there is generally a very extraordinary an widely distributed affection of the muscular system. Many of th muscles on being cut into look like pieces of fat, in which to the nake eye no trace of muscular tissue is visible. Under the microscope occasional narrowed muscular fibres may be visible in the midst of the adipos *tissue* (see Fig. 463), usually accompanied by strands of connectiv tissue. The muscular fibres, although varying in size and in general greatly narrowed, for the most part preserve their transverse striation. In some situations the fat may have, to a large extent, disappeared, so that fibrous tissue replaces the muscle.

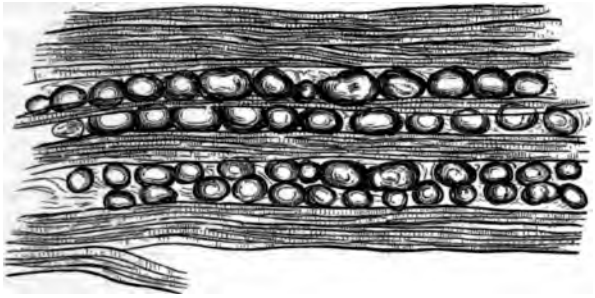


Fig. 463.—Muscle in pseudo-hypertrophic paralysis. There is chiefly adipose tissue with a few atrophied muscular fibres.

An idiopathic muscular atrophy has been described in which the wasting of the muscles has not been associated with increase of connective tissue or fat. This condition shows many analogies with that described above, occurring like it in several members of the same family, but not generally beginning in childhood.

Peroneal type of muscular atrophy (Progressive neural muscular atrophy).—In addition to the forms mentioned there is still another, which has been recently separated and described by Charcot and Marie in France, and in this country by Howard Tooth. It begins symmetrically, commonly in the peroneal muscles of the legs, or in the extensor muscles of the toes, and usually results in a deformity like club-foot. After the leg muscles the thigh muscles are involved, and only after years the arms, the small muscles of the hands being the first to suffer.

It is sometimes hereditary, and occurs mostly in males about the time of puberty. It holds an intermediate position between the forms due to changes in the central nervous system and those of purely muscular origin, and it is probably due to a neuritis.

III.—TUMOURS, SPECIFIC INFLAMMATIONS, AND PARASITES OF THE CORD.

Tumours of the cord and medulla proper are very rare, but it is not uncommon to find tumours of the meninges, and even of the bones, affecting the cord by pressure. The tumours of the meninges fall to be considered along with those of the membranes of the brain in a different section. We have here to do with those which involve the cord itself.

Of the tumours of the cord proper the **Glioma** is the most important. It arises usually in the central part of the cord in the tissue around the central canal, this tissue being mainly neuroglia. It may occupy a limited space, but sometimes it has a great longitudinal extension, even to almost the entire length of the cord. The cord is swollen, and, as the tumour-tissue is of nearly the same colour and consistence as the grey matter, the boundaries of the tumour may be indistinct. The glioma is sometimes associated with dilatations of the central canal and with malformations of the cord which will be considered further on. (See Syringomyelia.)

Myxoma and **Sarcoma**, usually glio-sarcoma, but in one case a proper spindle-celled sarcoma have also been observed. A case has been recorded by Ganguillet of a so-called **Cylindroma**, in which there were branching bodies whose ramifications presented gelatinous mantles.

The **Solitary scrofulous tubercle** is much less common in the cord than in the brain. It forms a hard cheesy mass, usually with a softer zone of tissue around it. The larger ones have usually their seat in the lumbar portion of the cord.

Syphilis seldom gives rise to proper gummata. When it does so the tumour, here as in the brain, takes origin in the meninges, and is hence at first superficial, although it may subsequently extend into the substance of the cord. The membranes over it are thickened and usually adherent.

Cysts do not occur in the cord as independent formations, but a cystic condition will be described further on as Hydromyelia and Syringomyelia.

Echinococcus and **Cysticercus** are exceedingly rare in the cord.

All forms of tumour, whether of the cord or meninges, are liable to interrupt the conduction of the cord, and so to produce paralysis. There will be also the usual ascending and descending secondary degenerations.

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SECTION IV.—CONTINUED.

C.—THE ENCEPHALON.

C. **The Encephalon.—Anatomical Introduction,** arrangement of fibres and centres. Functions of convolutions. Arteries of brain. I. **Malformations.** 1. Congenital smallness, microcephalus. 2. Hypertrophy. 3. Heterotopia. II. **Injuries.** Laceration of brain. III. **Lesions affecting the Circulation.** 1. Hyperæmia, anæmia, and œdema. 2. Occlusion of arteries; by embolism or thrombosis; effects, including softening of the brain substance; occlusion in chorea. 3. Thrombosis of the cerebral sinuses. IV. **Cerebral Hæmorrhage.** 1. From large arteries, chiefly due to aneurysm, sometimes to atheroma; influence of increase of blood pressure. 2. From nutrient arteries, may be from miliary aneurysms or atheroma. 3. From capillaries, chiefly complicating other forms. Appearances in hæmorrhage, and results; the apoplectic cicatrix and cyst. V. **Inflammation.** Acute localized encephalitis. 2. Abscess of the brain. 3. Chronic localized encephalitis. 4. Diffuse encephalitis, (*a*) in fevers, (*b*) in dementia paralytica, (*c*) in hydrophobia, (*d*) in tetanus. VI. **Atrophy and Degenerations.** Senile atrophy and other forms; secondary degenerations. VII. **Tuberculosis and Syphilis.** 1. The tubercular tumour. 2. Syphilis of brain and membranes; disease of arteries may lead to softening. VIII. **Tumours,** chiefly glioma and sarcoma, **and Parasites.**

Anatomical Introduction.—A knowledge of the course of the fibres in the encephalon is even more important than in the spinal cord and medulla, as these are liable to be interrupted in a more isolated fashion. It is of great consequence that the pathologist should have an acquaintance with the general relations of parts so as to identify the position of lesions. In this section nothing more is attempted than to indicate these general relations, the more intricate particulars being left to the special works on anatomy. In the actual work of post-mortem examination, it is important to note the exact locality of lesions on the spot. To assist in this, tracings may be made of the figures which accompany this section, or of similar ones, the positions of the lesions being entered in shading.

In the medulla oblongata, as we have seen, motor fibres, which have been in the lateral columns of the cord, come forward and form the anterior pyramids, in which they decussate. The sensory fibres are now behind, and they remain posterior to the motor in all the succeeding parts. In the **Pons Varolii (Fig. 464)** the motor fibres are in front, forming bundles (as shown in lower half of figure), but overlaid by the transverse fibres from the cerebellum. Besides these fibres, which are mainly in the anterior half of the pons, there are grey nuclei (shown in upper part figure), which continue up the series in the floor of the fourth ventricle. In the ns the principal nuclei are those of the sixth and facial, the motor and sensory ts of the fifth, and one of the nuclei of the auditory nerve. It is to be remem-red also that the fibres of these nerves in part at least traverse the pons, and are ble to be involved by a lesion, even when the nuclei are not reached.

In the **Crura cerebri**, or cerebral peduncles, the motor fibres are in front and ternal, forming the greater part of the **crusta**. Sensory fibres occupy about the ternal fourth of the crusta. Behind the crusta is the locus niger, behind which ain is the **tegmentum**, containing a rather complex mass of fibres and grey matter.

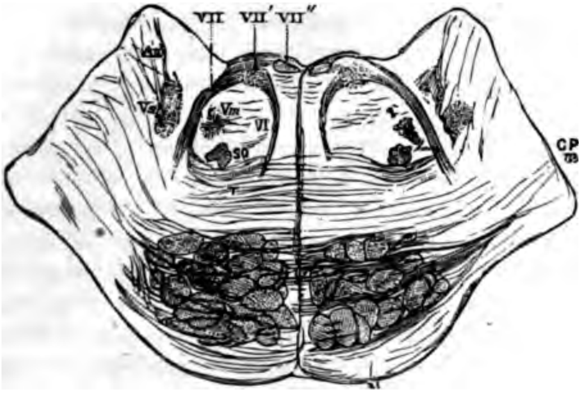

Fig. 464.—Pons Varolii. In lower half the transverse section of nerve bundles continued upwards from the cord is seen, the pyramidal tract being in front (or lower in figure). The Roman numerals and letters indicate the nuclei of cerebral nerves. (Quain.)

Above the crura the fibres are continued upwards, the motor still anterior and sensory posterior, in the mass of white substance called the **Internal capsule**. is here necessary to be somewhat more minute in the description of the relation the structures, as these relations are of great importance. When one of the ral ventricles of the brain is opened, certain masses of grey nervous tissue are n in its floor. In front there is a long brown prominence, rounded anteriorly, tailed behind. This is the **Nucleus caudatus**, which is often designated the us striatum, although really only one piece of it. Behind the nucleus caudatus he **Optic thalamus**, which is more bulky and rounded. It will be remembered t in opening the lateral ventricle almost no nerve fibres need be cut except commissural ones of the corpus callosum. The great masses of nerve fibres sing upwards are as it were pushed outwards by the lateral ventricle, and we e to cut into its floor in order to reach them.

rom the accompanying figure, which represents a horizontal section of the brain t below the floor of the lateral ventricle, the relations of parts may be gathered g. 465). Beneath and outside the nucleus caudatus (*NC*), and continuous above d externally with the great central white substance of the hemispheres—the rona radiata—there is a mass of white substance. This is the **Internal capsule**, in ich may be distinguished an anterior division *IK'*, a posterior division *IK*, and niddle part, the knee *K*. To the outside of and beneath the internal capsule lies mass of grey substance, the **Nucleus lenticularis** (*LN*), which on section has a ngular shape with the base turned outwards, and is seen to be divided into three pieces (shown on right side). It is generally regarded as a part of the corpus striatum and as being motor in function. The nucleus lenticularis extends a considerable distance from before backwards, and in its posterior parts the internal capsule (*IK*) lies between it and the optic thalamus, which has now largely taken the place of

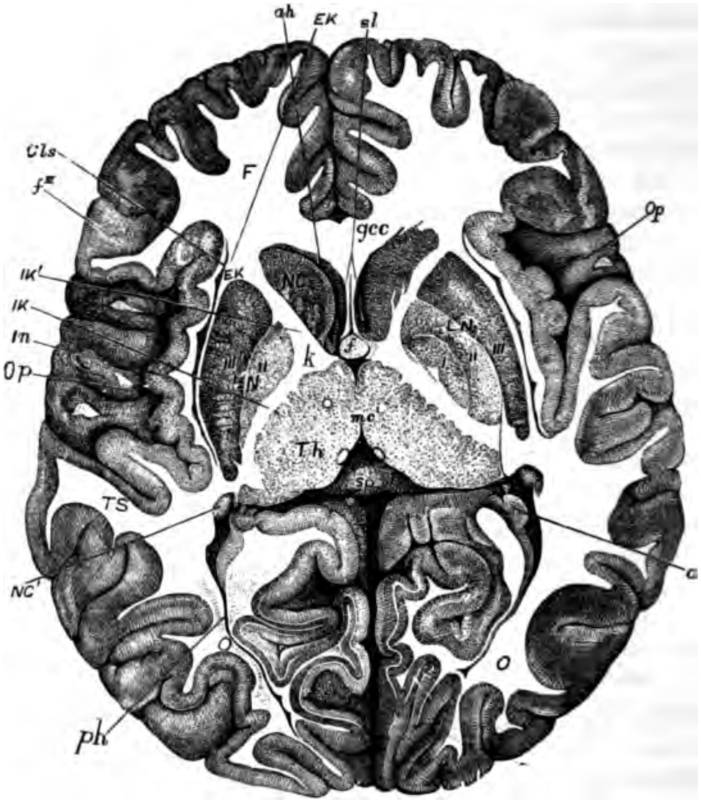

Fig. 465.— Horizontal section of brain of a child nine months old, the right side at a somewhat lower level than the left. *F*, frontal; *TS*, temporo-sphenoidal; and *O*, occipital lobes; *Op*, operculum; *In*, island of Reil; *Cls*, claustrum; *f'''*, third frontal convolution; *Th*, thalamus; *NC*, nucleus caudatus; *NC'*, tail of same; *LN*, nucleus lenticularis; *I*, *II*, *III*, its first, second, and third divisions; *IK*, internal capsule, posterior division; *IK'*, anterior division, and *k*, knee; *ah* and *ph*, anterior and posterior horns of left lateral ventricle; *gcc*, knee of corpus callosum; *sp*, splenium; *mc*, middle commissure; *f*, fornix; *sl*, septum lucidum; *a*, cornu Ammonis. (Ross and Flechsig.)

the nucleus caudatus. Outside the nucleus lenticularis there is a narrow band of white substance (*EK*), the **External capsule**—the capsules being named from their relation to the nucleus lenticularis. Outside the external capsule again and close to the convolutions (here the Island of Reil) there is a narrow band of grey substance (*Cls*), which is fancifully compared to a tape-worm, and is called the **Nucleus tæniæformis** or **Claustrum**. The anterior parts of the internal capsule contain motor fibres, and the posterior sensory; it is generally said that the anterior two-thirds are motor, and the posterior third sensory.

is to be remembered that the three nuclei we have referred to, the nucleus itus, nucleus lenticularis, and thalamus opticus, receive fibres from and give to the internal capsule. There are fibres passing upwards to the convolutions thers downwards to the lower centres.

ssing upwards, the fibres of the internal capsule are continued into the **Corona ta** or centrum ovale, containing the white substance of the hemispheres, and y be stated generally that in the corona radiata motor fibres are anterior and ry posterior. But besides these fibres there are multitudes which form comcations between one part of the convolutions and another, and altogether the ections here are very complicated.

e **Cerebral convolutions** and their arrangement may be studied in Ecker's , where the descriptions are very clear.

the lateral aspect of one of the cerebral hemispheres be examined (see Fig. 466), great landmarks should first be made out; these are the fissure of Sylvius

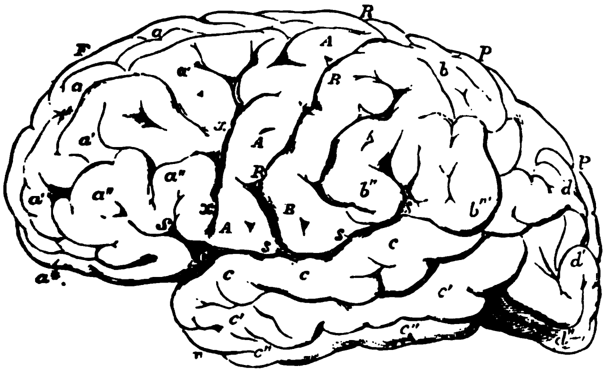

Fig. 466.—Left lateral aspect of cerebrum. Explanation in text. (QUAIN.)

', S), and the fissure of Rolando (*R*, *R*). There is no difficulty with the **Fissure lvius** of which the main or transverse arm is perfectly distinct, while its short nding arm near the front is easy to make out. The **Fissure of Rolando** passes uely forward from above downwards through the middle of the lateral aspect ne hemisphere from the longitudinal fissure above, almost to the fissure of ius below. This fissure can usually be recognized by the fact that it is bounded r lies between two convolutions which extend side by side upwards and backls from the fissure of Sylvius (*A*, *A*, *A* and *B*, *B*). There is frequently, ever, in front of it a sulcus which may be mistaken for it.

aving distinguished these two fissures the various lobes of the brain may now letermined. All in front of the fissure of Rolando, and above the fissure of rius, is **Frontal lobe**. The **Parietal lobe** lies behind the fissure of Rolando, and osterior extremity is bounded by a fissure which is best seen on the inner face he hemisphere, the **Parieto-occipital fissure**. This fissure, beginning about the e of the great median fissure, passes downwards and forwards on the inner face he hemisphere (*par. occ. f.*, Fig. 467). Behind this is the **Occipital lobe**. The aining lobe is the **Temporo-sphenoidal**, which lies below the fissure of Sylvius l extends backwards to meet the occipital lobe, from which it is indefinitely inguished.

Of the convolutions the easiest to determine are those bounding the fissure of Rolando, one of which belongs to the frontal and the other to the parietal lobe; these are called the **Ascending frontal** and **Ascending parietal convolutions** respectively. In front of the ascending frontal, the frontal lobe presents three layers of convolutions (a, a', and a'') which lie transversely and pass by their posterior extremities into the ascending frontal. These **Transverse frontal convolutions** are distinguished as the first, second, third, or superior, middle, and inferior. It is not to be supposed that these are single simple convolutions, they are rather complex, being broken up into smaller convolutions by numerous unnamed fissures. The inferior (a'', a'') is a very important one, and it can generally be easily recognized as it curves round the short ascending branch of the fissure of Sylvius (S). After curving round this branch it becomes continuous with the lower end of the ascending frontal. At this point the two convolutions form a somewhat triangular piece, and as this lies over and partially covers the island of Reil, it is often called the **Operculum** (in the position of $x\ A$ in Fig. 466). In addition to these we have still in the frontal lobe the **Supraorbital** convolutions (a^*), which have no arrangement that needs to be detailed.

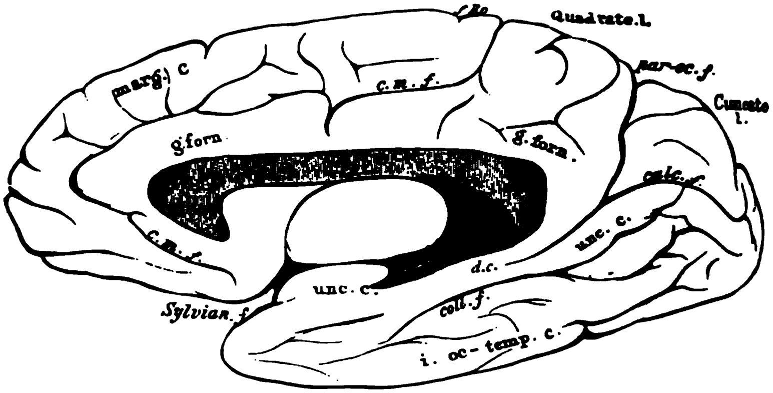

Fig. 467.—Internal aspect of right cerebral hemisphere. Explanation in text. (QUAIN.)

In the parietal lobe the **Ascending parietal convolution** (B, B, Fig. 466) is already known. Another easily recognized one is that which lies immediately above the fissure of Sylvius, and is called the **Supramarginal convolution**. The posterior portion of this convolution curves round the upper end of the fissure of Sylvius, and as it turns thus round an angle it is often called the *angular gyrus* (b'', b'''), and is important, as Ferrier has supposed it to be the seat of visual memory. The rest of the parietal lobe is divided into an upper and a lower portion by a longitudinally placed fissure—the intra-parietal fissure—which is often not very distinct. It arises close to the fissure of Sylvius behind the fissure of Rolando to which it at first lies parallel, and then passes backwards. The lobe is thus divided into the **Superior** and **Inferior parietal lobules**, the former being continuous in front with the ascending parietal convolution.

In the **Occipital lobe**, looking at the lateral aspect, **three transverse layers** of convolutions can be distinguished. These are named as in the frontal lobe, first, second, and third, or superior, middle, and inferior (d, d', d'', Fig. 466). On the der or **basal surface** there are two further layers which are continuous in front th those of the temporo-sphenoidal lobe and are named in common with them **erior occipito-temporal** convolutions.

The temporo-sphenoidal lobe presents on its lateral surface again **three trans- rse convolutions**, superior, middle, and inferior (c, c', c'', Fig. 466); the superior, unding the fissure of Sylvius and also called **Infra-marginal**, is continuous with e **angular gyrus**. The remaining two sets on the basal surface have been already entioned as forming, with those of the occipital lobe, the inferior occipito-temporal nvolutions.

On examining the **Internal aspect** of the cerebral hemisphere (Fig. 467) certain nvolutions are to be distinguished. The superior frontal convolution and the cending frontal and parietal convolutions are here partly visible. More distinctly the internal surface we distinguish in front the **Marginal convolution** (*marg. c.*) iich is continuous with the superior frontal and lies along the superior longitudinal sure. Immediately behind this convolution we come to the superior parietal bule which, on its mesial surface, is called the **Præcuneus** or **Quadrate lobe** (see ure). The parieto-occipital fissure is here very marked, and it is joined at an gle by the calcarine fissure (*calc. f.*) in such a way as to demarcate a triangular rface, the **Cuneus** (*cuneate l.*). On this aspect also appear the inferior occipito- mporal convolutions (*i. oc.-temp. c.*). Within this external ring of convolutions have now a deeper layer. Immediately bordering on the corpus callosum and llowing the fornix we trace from before backwards the **Gyrus fornicatus**. Having irted the corpus callosum from before backwards it turns round at its posterior tremity, and passes downwards into the **Gyrus hippocampi**. This gyrus is also ntinuous with the gyrus cunei and the median occipito-temporal. The gyrus ppocampi passes forward towards the anterior extremity of the temporo-sphenoidal be, where it terminates in a hook-like curve, the **Gyrus uncinatus** (*unc. c.*).

In the cornu Ammonis of the lateral ventricle there lies a convolution whose rface is turned inwards and forms an elongated rounded projection in the cornu; iis is the **Gyrus dentatus** (*d. c.*).

Functions of the convolutions.—The localization of function in the cortex of the rain is of so much practical importance that it is well, when opportunity offers, to miliarize the mind with the topography of the convolutions in relation to function.

The cerebellum.—There are only a few points which require notice here as to the eneral arrangements of the parts in the cerebellum. Like the cerebrum it is ivisible into two lateral hemispheres, the right and left lobes. These are united y a central piece, which is most marked on the under surface, called the vermiform rocess. The cerebellum is divided by many fissures which run horizontally and ave narrow convolutions called the **Folia**. One of these fissures, deeper than the st, and called the great horizontal fissure, divides the cerebellum into an upper d a lower portion. In its internal structure the cerebellum presents white matter iich runs outwards from the peduncles diverging towards the folia and forming a ee-like expansion, the **Arbor vitæ**. In the midst of the white substance in each misphere there is a small grey nucleus, not unlike the olivary body, called the **rpus dentatum**.

Arteries of the brain.—With a view to the identification of the numerous lesions the arteries in the brain, it will be proper here to refer briefly to the distribution these vessels. The **Circle of Willis** (see Fig. 471, p. 749) gives off at the base iree main arteries to the brain, the posterior, middle, and anterior cerebral. The **osterior cerebral artery**, besides giving certain central branches to be afterwards referred to, is distributed on the surface of the brain, supplying the greater part of the occipital and temporo-sphenoidal lobes with the exception of the upper temporo-sphenoidal convolution. The **Middle cerebral artery**, or the artery of the fissure of Sylvius, is of great importance as being much more frequently the seat of lesions than the others. Besides its central branches, afterwards considered, it supplies the middle district of the brain all round the fissure of Sylvius, including the parietal lobe, the posterior parts of the frontal lobe, and the superior convolution of the temporo-sphenoidal lobe. The **Anterior cerebral artery** is distributed to the anterior parts of the frontal lobe.

These arteries, with the exception of their central branches, run in the sulci of the convolutions, and divide into successive orders of branches which lie in the pia mater. The larger branches anastomose sparely, while the finer twigs are end-arteries (Duret). All the arteries hitherto considered run on the surface of the brain in the soft membranes. The actual nutrient arteries are branches of these, and penetrate from them into the substance of the brain. We may thus distinguish the larger arteries of the surface and the smaller or nutrient arteries.

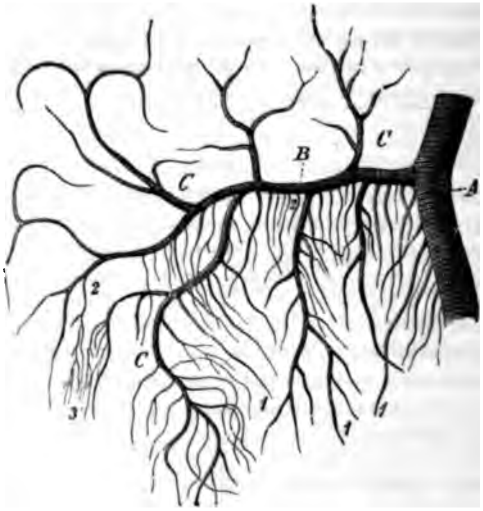

Fig. 468.—Arteries of the brain showing cortical distribution. *A*, a tertiary branch of a main artery; *B*, primary twig; *C*, *C*, *C*, secondary twigs. The nutrient arteries are seen to pass off from all these branches as fine hair-like offsets. (Ross after Duret.)

The **Nutrient arteries** again are divisible into two groups, which may be designated the cortical and central systems.

The **Nutrient arteries of the cortex** pass off not merely from the finer twigs of the larger arteries, but also from the larger branches (see Fig. 468). They are fine thread-like vessels which pass down perpendicularly into the brain substance. Some of them are short and supply the grey substance of the convolutions, others are longer and reach the white substance, their territory here extending to the boundaries of that of the central arteries. In stripping the membranes from the surface of the brain these nutrient arteries are seen like fine hairs emerging from the brain substance. If a portion of the soft membranes be now floated in water

e vessels will be seen like bristles passing from all the branches. All
ent arteries are end-arteries.
ntral nutrient arteries have a somewhat different arrangement from those
rtex. They are long vessels of larger calibre than the cortical ones, and
off from the main arteries very near their origin. The most important are
ich come off from the middle cerebral artery just outside its origin and pass
he **anterior perforated space** to the basal ganglia. Of these, three sets of
have been distinguished: (1) the *lenticular branches*, short twigs lying
which pass to the internal parts of the lenticular nucleus; (2) the *lenticulo-*
anch, a longer and larger vessel which lies outside the first and supplies
parts of the lenticular nucleus and adjoining parts of the internal capsule
ate nucleus; this branch is most frequently the seat of rupture with con-
æmorrhage; (3) the *lenticulo-optic* branch is posterior to the former and
the posterior part of the lenticular nucleus and the anterior part of the
lamus. The remaining central branches are supplied by the anterior and
cerebral arteries. The former sends branches which supply the anterior
he caudate nucleus, and the latter sends two sets, an internal and an
to the optic thalamus. All these central arteries are end-arteries.
teries of the pons and medulla oblongata are like the cortical arteries in
ll size and like the central ones in respect that they come off from large
d pass directly into the substance of the part.

I.—MALFORMATIONS OF THE BRAIN.

ıore considerable of these have been considered in the section
ral malformations. The principal forms are *anencephalus* accom-
y *acrania* or *cranioschisis*, *encephalocele* and *cyclopia*. The relation
to dropsy of the ventricles of the brain (hydrocephalus) has
n considered. It has been pointed out that hydrocephalus
g at an early period leads to these serious malformations, which
mpatible with life. But hydrocephalus sometimes occurs at a
iod, and the child is born with a *congenital hydrocephalus*, which
sometimes regarded as a malformation. It will be taken up,
, along with the other forms of hydrocephalus.

ngenital smallness or Aplasia of the brain.—This may affect
n as a whole or parts of it.

ncephalus signifies a general smallness of the brain, which is
associated with **Microcephalus** or smallness of the head, the
rm being frequently used as synonymous with the former. The
sually concerns the cerebrum chiefly, although other parts may
nvolved. The brain may be defective in structure as well as in
convolutions being small, irregular, or defective. The affection
due in some cases to a simple defect in formative power in the
matter, but it results sometimes from more definite pathological
ns in the fœtus. Thus there are cases in which it co-exists with
phalus. In these the size of the head may not be small, but

3 A

that of the brain may be seriously diminished. Ahlfeld, again, ascribes many cases of micrencephalus, where there is no existing hydrocephalus, to a dropsy at an earlier period. Premature union (synostosis) of the cranial sutures and synchondrosis of the basal bones have been assigned as causes of microcephalus; the cranium not being able to expand the brain remains small. The observations of Bourneville have shown that it is more than doubtful if this can be accepted as an explanation of the condition. Again, thickenings of the pia mater sometimes co-exist, and this indicates an early inflammation as the probable cause of the defect in the brain. Any considerable degree of micrencephalus is accompanied by idiocy.

The average weight of the entire encephalon in the adult is about 50¼ ounces in the male and 44¾ in the female, the weight ranging from about 43 to 60 ounces in the male, and 40 to 50 in the female, although there are exceptional cases both above and below that range. The average weight of the cerebellum is 5¼ ounces in the male and 4¾ ounces in the female; that of the pons and medulla oblongata is about 1 ounce in the male, and the same in the female. (See further in Quain's Anatomy.)

Parts of the brain are sometimes congenitally small. The convolutions may be imperfectly formed, or there may be asymmetry of the hemispheres. The cerebellum is also not infrequently imperfect. It may be as small as a walnut, or present various degrees of defect.

In a case reported by Fraser there was a congenital ataxia which was found after death to be due to smallness of the cerebellum (2½ ounces). Similar symptoms existed in a sister, who was presumably the subject of a similar defect.

2. **Hypertrophy of the brain.**—This is a condition rarely observed; but occasionally, without any hydrocephalus, a child is born with an unusually large encephalon. There are also cases in which, in later life, a hypertrophy of the brain takes place, sometimes acute, sometimes chronic.

3. **Heterotopia of the brain substance.**—Besides the extreme form of Encephalocele (see p. 49) certain cases of Hernia cerebri, in which there is no hydrocephalus, are regarded as belonging to this class. Sometimes also masses of grey substance are met with in abnormal situations, as in the midst of the corona radiata. Some of these cases may really be tumours of the brain, but they are congenital, and due to errors in development.

Porencephalus is a term used for defects of the brain in the form of gaps in the superficial parts penetrating more or less deeply into the cerebral substance. sometimes as deeply as the ventricles. The gaps are occupied by the œdematous membranes. The lesion is ascribed to inflammation occurring in the fœtus. There may be associated with it a congenital paralysis and atrophy of parts corresponding with the lesion in the brain.

In cases of **Idiocy** there is defect of the brain, and it may be in various forms. There may be micrencephalus or congenital hydrocephalus, or partial defects. There may be little beyond some traces of inflammation in the membranes. Similarly **Cretinism**, which is endemic in some localities and is often associated with goitre, is related to various lesions of the brain. In this condition, however, the defect in the brain seems to depend on the condition of the bones. The skeleton as a whole is stunted and deformed, and the bones of the skull show synostosis and premature synchondrosis, so that the elongation of the basal parts and expansion of the vault are variously hindered, the brain being correspondingly defective.

Literature.—For greater defects see under Malformations. *Micrencephalus*—VIRCHOW, Gesam. Abhand., 1856, p. 891; HITZIG in Ziemssen's Encyclopædia (with literature); AEBY, Mikrocephalie and Atavismus, 1878; BOURNEVILLE, Bull. de la Soc. anat. de Paris, x., 1896. *Defect of cerebellum*—FRASER, Glas. Med. Jour., xiii., 1880; GOULD, Path. Trans., xxxiii., 6; CLAPTON, Path. Trans., xxxii., 20. *Hypertrophy*—HITZIG, loc. cit.; VIRCHOW, Ges. Abhandl., 1856, Virch. Arch., xxxiii.; LEES, Dubl. Med. Jour., xxii., 1842; TUKE, Jour. of Anat. and Phys., xii., 1873; LANDOUZY, Gaz. Méd. de Paris, No. xxvi., 1874. *Heterotopia*—HITZIG, loc. cit.; VIRCHOW, loc. cit., and Virch. Arch., xxxviii., 1886; MESCHEDE, Virch. Arch., lvi., 1872; SIMON, Virch. Arch., lviii., 1883. *Porencephalus*—HESCHL, Prag. Vierteljahrschr., 1868, and Jahrb. f. Kinderheilk., xv., 1880; DE LA CROIX, Virch. Arch., xcvii.; BINSWANGER, ibid., cii.

II.—TRAUMATIC LESIONS OF THE BRAIN.

Laceration of the brain.—The brain may be injured directly or indirectly. In injuries involving fracture of the skull the brain is often simultaneously wounded, or the bone may be carried inwards and impinge upon the brain. On the other hand, the brain is often lacerated without a corresponding external wound or fracture of the skull, by so-called *contre coup.* When a person falling from a height alights on the head the solid cranium is suddenly arrested. The more mobile contents impinging against the internal surface of the skull are pitched back in the opposite direction. Hence in such cases there is often laceration both at a point corresponding with the injury to the skull and at a point more or less diagonally opposite. The latter is called laceration by *contre coup*, and it is sometimes more severe than the other.

The lacerated brain substance is torn and softened and there is more or less hæmorrhage. The hæmorrhage may be serious if any considerable vessel in the meninges be injured, but is not usually great from the brain substance itself. The injured parts are afterwards affected by inflammation, which in the case of compound fracture with a septic wound may be acute, leading to abscess, but in most cases is chronic. Such chronic inflammations, affecting brain and meninges, may persist for long periods, even enlarging their area and producing extensive destruction and shrinking of the cerebral substance. In the affected part the membranes are adherent and thickened, and the brain substance is indurated by new-formed connective tissue. Important nervous and mental phenomena may follow such lesions even when the injury to the head has not been great.

III.—LESIONS AFFECTING THE CIRCULATION IN THE BRAIN.

These conditions are somewhat variously associated with each other and with lesions of other kinds. They mostly imply local or general alterations in the volume of the blood and lymphatic fluid in the brain, and such alterations have somewhat complex relations, chiefly arising from the fact that the skull, in the adult at least, is a closed cavity with rigid walls, whose contents as a whole are scarcely capable of variation, although the fluid constituents are variously interchangeable.

1. **Hyperæmia, Anæmia, and Œdema.**—Hyperæmia in the brain, as elsewhere, is divisible into active and passive. **Active hyperæmia** occurs generally or locally in consequence of hypertrophy or over-action of the heart, especially when the arteries are atheromatous and unable to control the circulation. It also occurs in inflammations of the brain or meninges, and in various conditions of excitement of the brain, as the delirium of fevers, the early stage of general paralysis, the typhoid stage of cholera, in conditions of plethora, or excessive functional activity as over-work or over-strain, or from the action of alcohol and other agents such as nitrite of amyl. In these conditions it may be regarded as an inflammatory phenomenon.

Passive hyperæmia results most directly from thrombosis of the cerebral sinuses (see further on), but is also an occasional consequence of pressure on the jugular veins, or of disease of the heart or lungs leading to general venous engorgement.

The appearances visible after death in both forms are frequently insignificant, especially in active hyperæmia, the existence of which is usually a matter of inference rather than of observation. The over-filling of the vessels is most visible in the meninges, but there may be also a deepened colour of the convolutions, and the venous stems in them and in the white substance may be visibly dilated.

Anæmia or Ischæmia results mostly from obstruction of arteries (see below). It may also be a consequence of general anæmia, as from loss of blood, in which case it affects the brain as a whole. It may result from local pressure on the brain produced by tumours, extravasations of blood, or inflammatory exudations. Further, it may result from an unequal distribution of the blood, as in cases of dilatation of certain other vascular areas, as say, when rapid dilatation of the vessels of the domen follows the rapid removal of ascitic fluid; stenosis of the rtic orifice is another possible cause; and the condition may also arise om the loss of fluids from the intestine, as in certain cases of pro-acted diarrhœa in children associated with general malnutrition. cal anæmia in all these cases is liable to result in **softening** of the ain substance. Post-mortem, the brain substance, both grey and hite, is pale. The larger veins are full but the smaller vessels of the nvexity are empty, and there is an excess of cerebro-spinal fluid esent both in the pia and in the ventricles.

Œdema of the brain is also usually but a part of some other lesion. dema of the brain substance is a rare and in many cases a hypo-etical condition. The more definite œdemas affect the membranes d cavities, and will be considered further on. There is, however, an casional local œdema of the brain substance in the neighbourhood of emorrhages, tumours, and veins obstructed by thrombi, and it is so believed to occur at the outset of local inflammations. It may, wever, occur in Bright's disease, and according to Franke it is to this at some of the cerebral phenomena of uræmia are due.

The anatomical changes are not unlike those found in anæmia. The ain substance is moist and glistening. The fluid in the ventricles is creased as a rule. The meshes of the pia also contain an excess of uid. and the whole brain has a sodden aspect.

2. **Occlusion of arteries.**—This is a frequent and a serious lesion, ccurring mostly as a result of embolism or thrombosis.

Embolism occurs in the great majority of cases in connection with ld standing valvular disease of the heart, and especially in connection ith disease of the mitral valve, associated with stenosis of that orifice nd formation of thrombi in the left auricle. This condition of the alves is itself the result of a former endocarditis, and embolism of the erebral vessels is specially liable to occur when valves, already the seat f sclerotic change, are again attacked by the inflammatory process. t may also happen in the recent acute forms, especially when of he malignant or ulcerative type, with thrombus-formation on the denuded surface of the valves. In the former case the embolus results from the softening and breaking down or detachment of the thrombi in the left auricle, or from the detachment of fragments of fibrine or calcareous matter from the indurated curtains at the mitral orifice. In the more acute forms of endocarditis the embolus may result from detachment of a fragment of fibrine from the inflamed mitral or aortic valve. So also, but much more rarely, may thrombi in the aorta become detached and carried off. Emboli come very exceptionally from the lungs, but sometimes in gangrene of the lungs there is a thrombosis of the veins, and from fragments of fibrine carried off we may have septic embolism of the brain. A cancer of the lungs after penetrating into the pulmonary vein may produce embolism.

It is a matter of general observation that in cerebral embolism the **Middle cerebral artery** (or artery of the fissure of Sylvius) is the vessel plugged in the great majority of cases. It is also stated that the left middle cerebral artery is more frequently the seat of embolism than the right, but this has been doubted by competent observers. The frequency with which the middle cerebral artery is affected admits of easy explanation. As the vertebral artery arises from the subclavian nearly at a right angle, it is not common for an embolus to pass into it. But the innominate and the carotids, being nearly in the direct line of the current from the aortic orifice, readily receive any fragment. Again, the middle cerebral artery is the direct continuation of the internal carotid and an embolus will more readily be swept into it than diverge forward or backward. It is important here to bear in mind that the middle cerebral artery supplies the greater part of the basal ganglia, including nearly the whole of the corpus striatum and internal capsule and a part of the thalamus opticus. It also supplies the greater part of the motor convolutions.

Thrombosis of the cerebral arteries arises in consequence of some alteration of the walls of the arteries. It is predisposed to by weakness of the heart, but mere sluggishness of the circulation so induced will hardly cause thrombosis in a healthy artery, although it does so in the venous sinuses of the dura mater, where the circulation is naturally very much slower. Thrombosis is mostly induced by **Atheroma** of the arteries. The internal coat is thickened, and the surface is rough, while the calibre of the artery is already considerably encroached on, as Fig. 469 shows. Atheroma occurs mostly in old persons, and it is usually most pronounced in the larger arteries of the base, where there may be numerous yellow patches. But not infrequently it extends to the finer ramifications, and it is in these that it most readily leads to occlusion by thrombosis. The artery from which the figure is taken, for instance, had an external diameter of the eleventh of an inch. Whilst complete occlusion by thrombosis is unusual except in very small arteries, it may occur in those of larger size. In a case observed by the author one of the larger branches of the middle cerebral artery was thus affected, and an extensive softening in the temporo-sphenoidal lobe resulted. **Syphilitic disease** of the arteries is a much less frequent cause of thrombosis. It is met with in connection with gummata, and these may occur at any part of the surface of the brain. Thrombosis may also result around an embolus and extend backwards against the lood current. It may also occur in connection with various forms of neurysm of the cerebral vessels.

Effects of occlusion of arteries.—Here, as in other parts, the effects f occlusion depend chiefly on whether the arteries concerned have ufficient anastomosing communications or not. The arteries of the ircle of Willis anastomose freely, and occlusion of one of them leads ly to a very temporary derangement of the circulation. The larger anches anastomose sparely, and occlusion of them has much more rious effects. The nutrient arteries do not anastomose at all, and clusion of them has very evil results.

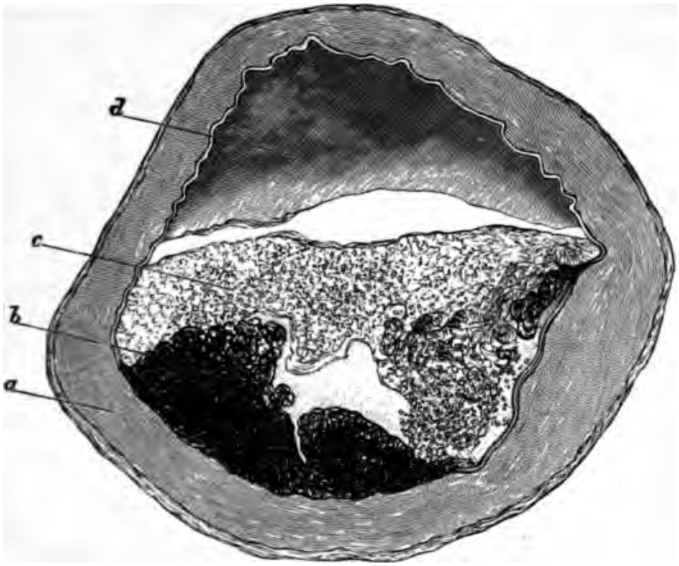

Fig. 469.—Diagrammatic sketch. Atheroma of cerebral artery. The greatly thickened internal coat is seen. In its substance are dark masses (*b*) in which margarine crystals are found. On the surface is a paler layer (*c*) consisting of partially organized thrombus; (*d*) blood occupying the remaining calibre. × 34.

The most direct result of occlusion of arteries is **Anæmia** of the part upplied. As the occlusion in the case of embolism is sudden, there is ften a very abrupt interference with the cerebral functions. In the ase of a large artery, such as the main stem of the middle cerebral, here may be a very extensive anæmia, leading to a fatal issue before he anastomosing circulation can be established.

Softening of the brain substance (*Ramollissement*) is a further conquence. This is really a necrosis with fatty degeneration of the rvous tissue, and it only occurs when the conditions are such that the rculation is brought absolutely to a standstill. This is the case when any of the nutrient arteries are obstructed, as these are end-arteries. The nutrient arteries which come off from the first part of the middle cerebral are the most exposed to obstruction from embolism, and hence softening of the central parts of the brain, especially in the region of the corpus striatum, is of somewhat common occurrence. It is important to notice that, for reasons to be afterwards considered, it is these arteries also which most frequently give rise to hæmorrhage.

But softening not infrequently occurs although the vessels occluded are not end-arteries. This is especially true where thrombosis is the cause of the occlusion. As we have already seen, thrombosis is common in connection with atheroma. Now this is a disease of old people, in whom the circulation is weak. Under these circumstances occlusion of a small peripheral artery may lead to softening, before the force of the blood has brought about an anastomosing circulation, all the more because many of the neighbouring arteries are also partially obstructed by atheroma. Even in the case of embolism there may be considerable cortical softening if the embolus has broken up and plugged several vessels at the same time, so as to interfere with the establishment of the anastomosing circulation.

The **Changes in the brain substance** in softening have already been incidentally considered. It will be a local lesion limited to the piece of brain substance to which the affected artery is distributed.

Softenings have often been distinguished according to the colour presented by the affected brain substance, so that **white, yellow,** and **red** softenings have been described. For the most part the colou depends on the blood mixed with the nervous tissue, and the amoun and condition of the former can hardly be regarded as a chief characteristic of the softening; the colour is therefore not of primary importance.

We have seen already that softening of the brain substance is really due to a **Necrosis.** The result of the death of the nervous structures is their disintegration. The nerve fibres very rapidly break up; the myeline of the medullary sheath coagulates and escapes from the primitive sheath, and afterwards breaks up into fine fat granules. The ganglion cells are more resistant, but they also become granular and gradually disappear. The cells of the neuroglia and the cells of the walls of the vessels undergo fatty degeneration. These structures become filled with finely divided fat, so that the neuroglia cells are converted into characteristic **Compound granular corpuscles** and the cells of the vessels are converted into aggregates of fat granules at intervals along the vessels (Fig. 470). So far as the neuroglia cells are concerned it is probable that in some cases they pick up fat arising e disintegrated myeline. It is not so clear that the cells of the ssels do this, and there is here, probably always, a proper fatty ation. Besides the neuroglia cells there may be present in the œboid cells, or these may pass into it after the occurrence of the , and these also become occupied by granular fat. In this way e, frequently, large numbers of compound granular corpuscles are very conspicuous when a piece of the softened tissue is d in the fresh state under the microscope. A ready means of uishing true pathological softening from a mere post-mortem is afforded by the presence of these cells. In true softenings e present in large numbers and afford a highly characteristic nce.

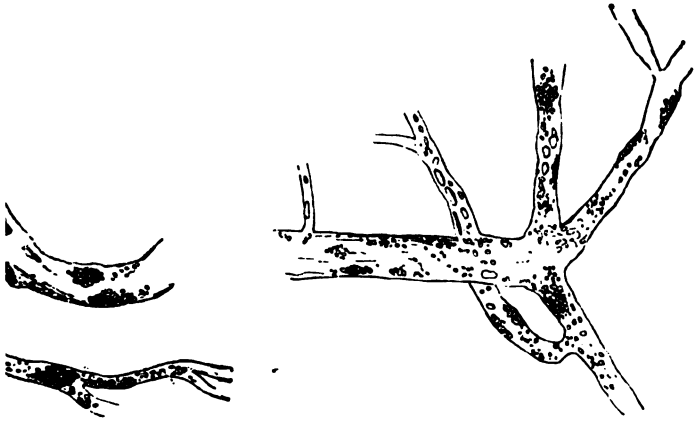

Fig. 470.—Fatty degeneration of the vessels in cerebral softening. (Paget.)

me cases, as already mentioned, the softened brain substance is mixed with blood. At first the blood gives a red colour to the g. But as time goes on the colouring matter is dissolved out of corpuscles and diffused throughout the softened structures, as to some extent in the brain substance around. In that case the ecomes less intense and merges into yellow, or the colour may ish- yellow from the outset. It will be seen from this that red low softening run together, and that the latter is often merely stage of the former. If there is very little blood in the vessels oftened part then the colour is white or grey. This is mostly hen death has occurred very soon after the occlusion of an

ultimate disposal of the necrosed piece of brain substance occurs ciples already considered. The softened brain substance has ely the characters of a fatty emulsion, which is gradually absorbed. A chronic inflammation occurs around, just as in the case of a hæmorrhage, and in a similar fashion connective tissue is produced, taking the form of a cyst or cicatrix, according to circumstances. The resulting cyst or cicatrix is not always to be distinguished from that of a cerebral hæmorrhage. Usually the latter presents more distinct pigmentation, but the former may also present pigment granules and crystals.

Other forms of softening are of less consequence than those from occlusion of arteries. Softenings are very frequent around extravasations of blood. They are partly due to mechanical destruction, but also to anæmia from the pressure of the blood. Softenings around tumours are similarly due to anæmia. There is occasionally a softening from localized inflammation, more especially such septic forms as lead on to abscess. A softening of the brain around the ventricles also occurs in connection with the hydrocephalus of tubercular meningitis (which see).

Occlusion of arteries and other conditions in chorea.—The frequent association of chorea with acute endocarditis has suggested the view that it may have its origin in embolism of the arteries and capillaries of the brain, multiple embolism with softening having been found in some cases, but not in all. Embolism, however, is only a coincidence related to the endocarditis, and not necessarily connected with the pathology of chorea. This, indeed, is evident from the fact that acute endocarditis is not infrequently absent in cases of chorea. Other changes in the vessels have been observed, such as dilatation of the arteries and veins throughout the substance of the brain and spinal cord, exudations or small hæmorrhages, sometimes with blood crystals, around the vessels. These lesions, however, are by no means constant, and are to be regarded as consequences of irritation of the brain, or as coincident phenomena.

In chorea there is an irritant present in the blood, presumably the same irritant as that in acute rheumatism. It attacks the nervous system, producing hyperæmia and exudation from the vessels. While the whole central nervous system is more or less affected there are certain parts specially involved, these parts being what have been called the accessory portions of the nervous system. It may be supposed that the fundamental and simpler parts of the brain and cord are more stable than the accessory parts, and that when attacked by an irritant the latter will give way first. The anatomical distribution of the lesions suggests that this is so, and the symptoms of chorea indicate disorder in "movements which are acquired, and which are probably only learned by a long apprenticeship" (Hughlings Jackson). On the other hand, chorea has been regarded by some as due to an infection," but so far there is not much evidence forthcoming in pport of such a view, although, according to Osler, Pianese is said to ve isolated a bacillus from the nervous system of a choreic patient, ich when inoculated into animals caused death with muscular itchings and convulsions. From the central nervous system of these imals the same bacillus could be obtained in pure culture. By others phylococci have been obtained in fatal cases.

3. **Thrombosis of the cerebral sinuses and veins.**—These venous annels are somewhat frequently the seat of thrombosis. The agulation may have its starting point in an inflammation propagated m a neighbouring structure, in which case it is usually a **septic rombosis.** The most frequent origin of such inflammation is disease the ear, but it may follow on injury to the head, inflammations of e skin of the face and scalp, especially erysipelas, and of the bones. all these cases the thrombosis usually has its starting point about e base of the skull, and especially in the lateral and petrosal sinuses.

There is, however, another class of cases in which the thrombosis has more obscure origin, and seems sometimes even spontaneous. The ood simply coagulates in the sinus, and it is usually in the longitudinal nus that the coagulation begins. In most of these cases the person is a state of debility, and the thrombus may be regarded as **Marasmic** its origin. But there are cases in which there is no obvious weakess of the heart, and the coagulation has no apparent cause. The calization of the thrombosis suggests that it has been occasioned by agnation of blood. The sinuses are rigid tubes incapable of narrowing hen the circulation is slow, and they are intersected by bands of conective tissue. The longitudinal sinus also is so situated that, at its iddle part at least, the blood passing from the cerebral veins flows pwards to it against the force of gravitation (see p. 79), and at right gles to the current in the sinus.

The **Effects** of thrombosis of the sinuses will vary according to the use. If due to the propagation of inflammation from neighbouring ructures, then a suppurative phlebitis may result, with **Meningitis,** d even **Abscess of the brain.** There are, however, cases of abscess the brain without meningitis, in which the inflammation seems to ve extended along the veins either in their interior or in their eaths.

In marasmic thrombosis the results are those of passive hyperæmia. he veins which open into the sinus are greatly engorged, and the rombosis may extend into them. It is here chiefly the longitudinal nus that is concerned, and the veins which open into it are those of e cerebral hemispheres. These may stand out as prominent worm-like cords, filled with dark coagula. In most cases the blood finds its way by other routes, and there may even be, after a time, a re-establishment of the circulation in the sinus. Sometimes, however, the obstruction in the veins is such as to lead to **Hæmorrhage.** This is usually in the form of numerous capillary hæmorrhages, but sometimes there is along with this a large effusion of blood in the substance of the brain and under the soft membranes. The seat of such hæmorrhages is usually the superficial and upper parts of the hemispheres, and they are frequently multiple.

Gowers alleges that a primary thrombosis of the cortical veins without sinus thrombosis not infrequently occurs, and is a not uncommon cause of hemiplegic attacks in young children, ushered in by convulsions which may be unilateral.

IV.—CEREBRAL HÆMORRHAGE.

By this term is meant bleeding into the substance of the brain. The blood, which may be large or small in quantity, pushes aside the brain substance, tearing for itself a cavity where it coagulates. With the doubtful exception of certain diseases of the blood, where the hæmorrhage may possibly be by diapedesis, there is always rupture of one or more vessels.

In a previous page reference has been made to the two orders of cerebral arteries, and the difference in the circumstances of hæmorrhages from these is such that we must consider them separately here.

1. **Hæmorrhage from the larger cerebral arteries.**—We have seen that these vessels run in the sulci and fissures of the brain, involved in the meshes of the pia-arachnoid, and it might be supposed that their rupture would give rise to meningeal rather than cerebral hæmorrhage, and so it is usually stated. But this is not the case. The blood nearly always finds its way into the brain substance, where it is found usually in much larger quantity than in the meninges, so that the case has much more the characters of cerebral than of meningeal hæmorrhage. There is usually some blood in the meninges occupying the sulci between the convolutions, and it may even be considerable, extending to the base and perhaps covering the optic commissure; but usually the amount is small, and on account of the large cerebral hæmorrhage, is apt to be overlooked. It is very rare indeed for the blood to escape to the surface and appear in the cavity of the dura mater. Any appearance of blood in the meninges, however, should at once direct attention to the larger cerebral arteries as the probable source of the hæmorrhage.

The explanation of the extension of the blood into the brain substance suggests itself when we consider the circumstances of the parts.

When rupture of such an artery occurs the blood tears its way around; it passes into the loose connective tissue, and by and by reaches the surface of the brain. Here the tissue, being soft, tears readily, and the blood rapidly passes inwards. On the other hand the connective tissue on the surface is tough and divided by numerous bands and partitions, and the blood will tear it with difficulty. The blood may work its way from space to space in the connective tissue, but this takes time, and probably needs considerable pressure. There is another circumstance which probably has to do with the blood so constantly finding its way into the brain substance. As we shall see afterwards, a large number of the cases of hæmorrhage in this situation are from rupture of aneurysms. Now an aneurysm will probably project more readily towards the surface of the brain where the substance is soft, than in other directions, and when such an aneurysm ruptures it may do so directly into the brain.

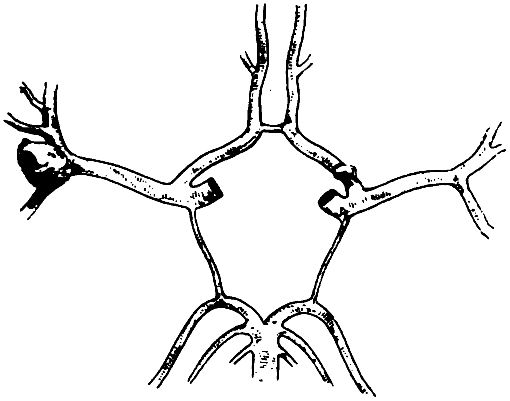

Fig. 471.—Aneurysms of larger cerebral arteries. A large one at the bifurcation of the left middle cerebral. There is an aperture at its summit, from which fatal hæmorrhage occurred. A small one near the origin of right anterior cerebral.

The Cause of the rupture of these larger arteries is to be sought for in disease of their walls and increase of the blood-pressure.

The commonest cause is **Aneurysm** of these arteries, which is of remarkably frequent occurrence. The great majority of the cases of cerebral hæmorrhage occurring before the age of fifty years is due to the rupture of aneurysms of these larger arteries. The aneurysms are mostly thin-walled and therefore prone to rupture. Their most frequent seat is on the middle cerebral artery or one of its branches in the fissure of Sylvius, but they may occur on any of the arteries of the brain and are not infrequently multiple (see Fig. 471).

The frequent occurrence of these aneurysms and their serious import suggests an inquiry into the causes of their formation. In the first place the arteries are thin-walled and are placed in a loose tissue, so that they very readily undergo dilatation. Any local injury to the wall may be the starting point of the dilatation. This is often effected by **Embolism.** In a large proportion of cases the aneurysm is associated with valvular disease of the heart, and an embolus imperfectly obstructing an artery, especially if it be a cretaceous piece broken off from a valve, may readily injure the wall so as to allow of dilatation. Ponfick has found that in a considerable proportion of cases of acute endocarditis there is embolism, with either fully formed or incipient aneurysms. Another indication of the origin from embolism is that the aneurysm is frequently at a bifurcation. The bifurcation of an artery is a common situation, as in Fig. 471, and more particularly the bifurcation of the internal carotid into middle and anterior cerebral. The aneurysm in that case is almost a bulged out continuation of the carotid, and this suggests an embolus pitched against the projecting angle between the branches. When they have an origin such as this the aneurysms will be specially thin-walled and partake of the characters of false aneurysms. This mode of origin also goes far to explain the greater predominance of these aneurysms in the middle cerebral artery, which, as we have seen, is especially liable to embolism. Another occasional cause of cerebral aneurysm is **Atheroma.** This disease injures the vessel-wall and produces obstruction, and it may lead to aneurysm on the one hand by weakening the wall, and on the other by locally increasing the blood-pressure on the proximal side of the obstruction. Syphilitic disease is also assigned as a cause of aneurysm.

Atheroma of the larger cerebral arteries is a frequent lesion, and it is sometimes associated with hæmorrhage in the substance of the brain. The hæmorrhage is not from the larger arteries at present under consideration, but from the nutrient arteries, to the more considerable of which the atheroma may extend.

2. **Hæmorrhage from the nutrient arteries.**—As these vessels run in the substance of the brain the hæmorrhage is always cerebral and rarely extends to the meninges. It might be supposed that as the nutrient vessels are small the hæmorrhage from them would be small, and in many cases it is so; but when bleeding has once begun, the blood tearing the brain substance ruptures other vessels, and there is often a considerable effusion of blood.

Hæmorrhage of any consequence rarely occurs from the cortical nutrient vessels, but is very common from the **central nutrient arteries.** The circumstances of these latter go far to explain this. They arise from large stems, mainly from the middle cerebral artery immediately after its origin from the internal carotid. It is clear that the blood here will be at a pressure not much less than that of the aorta, and any variations of pressure will tell readily. On the other hand, the cortical vessels mostly arise from fine vessels in which the blood-pressure has been reduced by successive division and sub-division.

As to the **Causes** of hæmorrhage in these arteries, **Aneurysm** again rs the most important part. As the arteries are small so are the urysms, but they are numerous in the same person. Such aneurysms e been called by Bouchard and Charcot **Miliary aneurysms.** They ır in every region of the brain, but are most readily detected on surface of the convolutions, where, on stripping off the pia mater

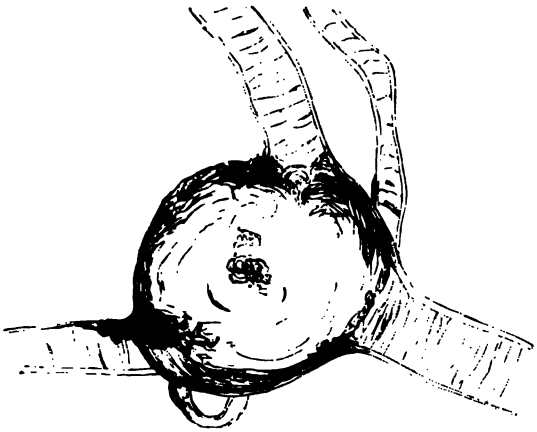

Fig. 472.—Sacculated miliary aneurysm of a nutrient artery of the brain. The aneurysm is about the twentieth of an inch in diameter. × 27.

ı the convolutions, they may be seen as small red or brown spots. en examined under the microscope they have all the characters of nary aneurysms. Most of them are sacculated (Fig. 472), but some

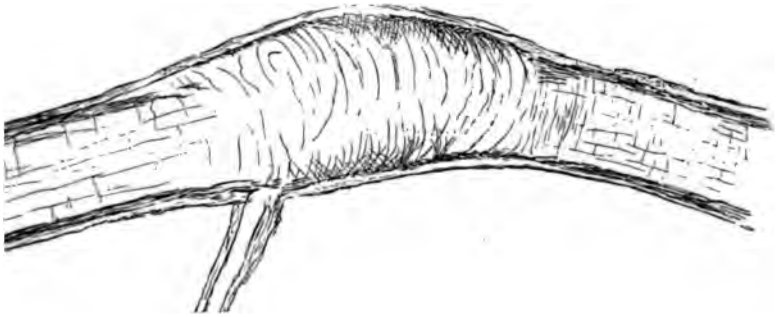

Fig. 473.—Fusiform miliary aneurysm. × 27.

fusiform (Fig. 473). It is stated that the cause of their formation sclerosis of the walls of the arteries, involving first a formation of ıd cells in the external coat with subsequent development into ous tissue. According to Recklinghausen, however, the first lesion rupture of the media—an origin which, considering the mode of ıation of aneurysms generally, seems a very probable one. In that case the sclerosis of the wall is to be regarded as the result of an inflammation secondary to the injury. **Miliary aneurysms** are mostly met with in old people; in persons above fifty cerebral hæmorrhage is, in the larger proportion of cases, due to rupture of miliary aneurysms.

In a case observed by the author there was frequently in the arteries a fatty degeneration affecting chiefly the internal coat. This was present in patches in a large number of vessels of small size. In connection with it there was sometimes a partial dilatation, an aneurysm obviously forming, and also fully formed aneurysms. Older and more recent hæmorrhages were connected with the aneurysms, and there was one very large fatal hæmorrhage.

Although the aneurysms are present in all regions of the brain, rupture seldom occurs except in those of the central arteries. The explanation of this has already been indicated, and it has been mentioned that the **lenticulo-striate branch** is pre-eminently that from which hæmorrhage occurs.

Atheroma, with increased blood-pressure, is occasionally a cause of hæmorrhage from the nutrient arteries. It is difficult to understand how atheroma, which consists in a thickening of the intima, should lead to hæmorrhage. It has been pointed out, however (see p. 552), that the atheromatous patch often produces injury and rupture of the media, thereby leading to aneurysm in some cases. In like manner, in such small thin-walled vessels as the nutrient arteries it may predispose to rupture. It is doubtful if rupture actually occurs without an **increase in blood-pressure.** Hence the coincidence of atheroma with chronic Bright's disease—in which the general blood-pressure is raised—not infrequently leads to cerebral hæmorrhage.

Atheroma is not a frequent disease in the smaller arteries of the body. It is very common in the larger arteries of the brain, and extends even to the smaller branches of these arteries in the sulci. It does not usually affect the cortical nutrient arteries, but not infrequently extends to the larger central arteries, especially those going to the basal ganglia. As these arteries are, for their size, exposed to a higher blood-pressure than others, and as they are surrounded by the soft brain substance, they rupture more readily. It will be noted that it is these same arteries, and more particularly the **lenticulo-striate** branch, which are most frequently the seat of rupture from aneurysm.

3. **Hæmorrhage from the capillaries.**—A certain amount of capillary hæmorrhage generally accompanies all larger bleedings. The explanation of this seems to be that the pressure of blood produces such obstruction of the vessels around, that frequent leakage occurs from the capillaries. In **thrombosis of the sinuses and veins** there is also capillary hæmorrhage (see above). Again, embolism may cause capi

ry hæmorrhage, and, as we have seen, the blood is often mixed with e softened brain tissue. Septic embolism, as in ulcerative endocarditis d pyæmia, leads to capillary hæmorrhage. Lastly, we may have akage from the capillaries in scurvy, purpura, leukæmia, and other orbid states of the blood.

In capillary hæmorrhages the collections of blood are generally small size, forming a congeries of red puncta. But if very frequent nd closely set they may run together and form a considerable ffusion.

Appearances of the brain in hæmorrhage.—The appearances pre- ented when a person dies soon after the occurrence of hæmorrhage are fficiently characteristic. The effused blood increases the contents of he skull, and in order to afford accommodation for it there must be ome displacement and crushing of the brain substance. If the æmorrhage be at all extensive we find on opening the skull that the orresponding hemisphere is bulged outwards and perhaps projects eyond the middle line. The convolutions are more or less flattened, nd there is a certain dryness and glazing of the surface which indicate hat all available fluid has been absorbed to make room for the addition ade to the contents of the skull. These are all indications of increased ressure within the skull, and during life this increase of pressure auses symptoms referable to the brain as a whole or to parts removed rom the seat of hæmorrhage. It sometimes happens that the appear- nce of blood in the membranes suggests the existence of hæmorrhage efore the brain is laid open, and this will be especially the case when upture of an aneurysm of a larger artery or thrombosis in the sinuses as been the cause. On cutting into the brain substance the appear- nces will vary to some extent according to the cause and extent of the æmorrhage. If there are numerous small hæmorrhages closely set ere will be much softening of the brain, and the brain substance will e mixed with blood. If the hæmorrhage be large the blood will be ore pure. In any case the blood produces softening in the parts ound, which may be stained with the blood colouring-matter. As ready mentioned, there are usually red spots from capillary hæmor- age around the clot. The clot itself is mixed with the debris of brain bstance, and the internal wall of the cavity in which it lies has an egular character.

If the patient die almost immediately, the clot is exactly like an inary gelatinous post-mortem coagulum. But if he survive a day or o, it is more drawn together, somewhat firmer, and is of a browner our. This is sometimes peculiarly manifest at the peripheral part, that a kind of capsule may be formed of condensed fibrine.

In washing away the clot from a cavity made by a hæmorrhage one often isolates many small arteries with round knobs at their extremities. These are arteries which have been torn across by the accumulating blood. The torn arteries have withdrawn within their sheaths, and these latter have become distended with little plugs of blood which have, in the manner already described, contributed to the stilling of the hæmorrhage. These little swellings may be readily mistaken for miliary aneurysms.

The observations of Dürck are interesting in regard to the changes which occur in the blood-corpuscles and their pigment after hæmorrhages in the brain. These changes, which have been already referred to, consist mainly in swelling up of the red corpuscles, discharge of their pigment, and the conversion of the latter first into **hæmosiderin**, and then into **hæmatoidin** (see page 394). The presence of hæmosiderin is detected (either in the fresh state or in sections made after hardening in Müller's fluid or alcohol) by the use of dilute solutions of ferrocyanide of potassium and hydrochloric acid. From his experiments in the lower animals, a kind of time-table has been constructed by Dürck, which may approximately be applied to human pathology. From the second day after a cerebral hæmorrhage the corpuscles begin to swell and give up their pigment. On the third day amœboid cells containing red corpuscles are first seen. These red corpuscles undergo shrinking from the fifth day. On the sixth day there is the first appearance of hæmosiderin, which is diffused in the tissues. On the tenth day the hæmosiderin is collected into the contractile cells, but still in solution. On the twelfth it begins to become granular inside the cells. By the eighteenth the granular pigment begins to get free by disintegration of the cells. About the twenty-fifth day there begins a finely granular precipitation of the pigment and loss of its iron, which by the thirty-fifth day has made essential progress. From this time the hæmatoidin increases, and by the sixtieth day it is the only form of pigment present, and it is entirely extra-cellular. By this time crystals, which are identical with those of bilirubin, may be present.

Disposal of the clot. The Apoplectic cicatrix and cyst.—The pigment of the coagulum is disposed of in the manner indicated above. It first stains the surrounding brain tissue, in which we often find a rosy or rusty colour. It finally assumes the form of hæmatoidin, crystals of which are frequently met with in connection with old hæmorrhages, even years after their occurrence.

The further disposal of the blood-clot is effected by a process analogous to the organization of a thrombus in a vein or artery. The process is one of chronic inflammation with the result that a vascular tissue is produced, which, forming around the clot, takes part in its absorption by penetrating its substance, while also forming a capsule and fencing it off from the surrounding tissue.

Through time the contents are absorbed and there may result, as in the case of softening of the brain, a **Cicatrix**. In many cases, however, the absorbed matter is replaced by clear fluid and a kind of cyst is the result, the so-called **Apoplectic cyst**. The cyst is not merely a sac containing fluid, but it is generally intersected by connective tissue trabeculæ in the form of a network. It is indeed more an œdematous cicatrix than a cyst. It has already been noticed that similar cysts and cicatrices occur as a result of softening of the brain. These latter, however, do not commonly show blood crystals in their walls, whereas the true apoplectic cyst may present them even at a late date.

The apoplectic cyst may be compared in its origin with a cicatrix ; it arises by the formation of connective tissue and fills the place of tissue lost, and it is only because, being situated in the midst of the brain substance, and being unable to contract that we have a cyst rather than a cicatrix. In this respect it may be compared with the organized thrombus as shown in Figs. 23 and 24, pp. 83, 84, in which the shrinking of the new-formed connective tissue produces dilated blood-vessels, whilst here it is merely spaces which are produced. If the hæmorrhage has been near the surface of a ventricle or of the brain itself we may have a cicatrix ; or a cyst, by thickening of the trabeculæ and gradual drawing together of the parts, may be converted into a cicatrix. In the case of cicatrices occurring thus on the surface of the brain the soft membranes are depressed and puckered and firmly adherent to them. The cicatrices, like the cysts, often present some remains of blood-colouring matter.

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V.—INFLAMMATIONS OF THE BRAIN.

These embrace a very extensive and varied set of conditions, some of which have little in common. Thus there are localized inflammations of an acute kind, going on sometimes to the formation of abscesses ; chronic localized inflammations ; inflammations diffused throughout the brain ; inflammations extending to the brain substance from the membranes, etc.

1. **Acute localized non-septic encephalitis.**—We have already seen that, around and in the midst of hæmorrhagic foci and cerebral softenings, there are inflammatory manifestations, evidenced by the presence of leucocytes containing fat granules. The inflammatory process does not go on to suppuration, but results in the formation of connective tissue, constituting a cyst or a cicatrix.

2. **Abscess of the brain.**—Abscess of the brain being, like abscess elsewhere, a septic process, arises by the implantation of pyogenic microbes in the brain substance. The disease is a somewhat frequent one. The abscess is usually single, but occasionally there is more than one.

Causation and mode of infection.—The brain being enclosed in several envelopes, one of which is a bony case, the pyogenic microbes can only find access to it either by lesions of the enveloping structures, or by means of the arteries. The latter is a very unusual mode of infection, but it has been met with, especially in cases of disease of the lungs characterized by suppurating cavities. In two cases in which thrush was coincident, the abscesses in the brain contained growths of the oïdium albicans. In the great majority of cases it is by the extension of septic processes from the bones of the skull that abscesses of the brain are brought about.

Given a septic inflammation in any part of the cranium, there are several ways in which the infection may spread inwards. There may be a direct extension from the bone to the dura mater. In that case a **septic pachymeningitis** is the result. Pus may collect inside the dura mater and may be limited by adhesions, so as to lead to a **subdural abscess**, perhaps with erosion of the brain. Or without any considerable accumulation of pus between the dura mater and the bone, the septic process may advance into the brain. There is usually in this case adhesion of the dura mater to the brain and some softening of the latter.

Again infection frequently travels **by the veins and venous sinuses.** A septic inflammation of a cranial bone may directly involve the wall of a vein or sinus. Thrombosis is thus induced, and as there are septic agents present, a **thrombo-phlebitis** is the result. The extension may be directly to one of the sinuses of the dura mater. On the other hand the extension may be first to one of the veins of the diploë and thence to the sinus. The veins of the diploë open partly into veins outside the skull and partly into those inside. In the latter case thrombo-phlebitis is liable to extend to the intra-cranial venous sinuses. As the most frequent seat of the original disease is the temporal bone, the extension, whether directly or by the veins of the diploë, is usually to the sigmoid and lateral sinuses. In this connection it is also of consequence that the posterior temporal vein of the diploë opens into the lateral sinus. On the other hand, it is to be remembered that the intra-cranial sinuses receive blood from the cerebral veins, and there is thus a communication between the bones and the cerebral substance. The thrombosis which accompanies the process is liable to block the sinuses, and the blood may in consequence even partially regurgitate into the veins of the brain, carrying septic agents with it, or there may be a propagation of the septic thrombosis into these veins.

In this mode of extension there is liable to be a septic **Lepto-meningitis** from the infection spreading to the pia-arachnoid. Abscess of the brain may therefore be associated with that disease, or either abscess or lepto-meningitis may occur alone.

A more unusual and possibly more doubtful mode of extension is along the perivascular lymphatics. The infective process may possibly penetrate along the outside of the veins without producing a septic thrombosis of the veins themselves.

The primary septic inflammation of the bones has, in the majority of cases, its origin in **suppurative disease of the middle ear** (*otitis media*). It is very seldom that an acute otitis media, even though it be suppurative, leads to septic inflammation inside the skull. It is usually the chronic cases, in which the tympanic membrane has been lost and there has been, it may be for years, a discharge from the external meatus. The suppuration in the middle ear affects the mucous membrane, which is here closely connected with the bone and acts as a periosteum. Hence the bone is liable to be affected, becoming carious or even undergoing necrosis. The tympanic cavity and mastoid cells both send blood into the sinuses of the dura mater by means of veins which pass through the bone; those of the tympanum passing into the petrosal sinus and those of the mastoid cells into the lateral sinus.

The abscesses arising from ear disease are usually situated either in the **temporo-sphenoidal lobe**, or in the **cerebellum**. In the latter case the extension has occurred for the most part by the sinuses and veins.

Injuries to the head sometimes give rise to abscess of the brain by extension of the septic process. Compound fractures with freely open wounds have seldom this result. It is mostly punctured fractures where infective matter is carried deeply inwards. There may even be a septic extension without fracture where the bones of the skull have been exposed in a wound and dirt ingrained into them.

Disease of the nose and orbit are rare causes of cerebral abscess, and it is only when the bones are affected, as in some cases of syphilis, that extension will occur. **Septic inflammations of the skin of the face and**

of the scalp, more particularly erysipelas, sometimes lead to septic lepto-meningitis, but seldom to abscess of the brain. The extension here occurs by the veins, a thrombo-phlebitis extending, it may be, from the orbit whose veins have communications with the cavernous sinus inside the skull.

Formation and character of the abscess.—The abscess begins presumably with a small softening which goes on to suppuration. The fully formed abscess contains a thick pus, usually greenish in colour, and in the case of ear disease generally exhaling a pungent putrid odour. In many cases the abscess is really a chronic one and the pus corpuscles are disintegrated. It is bounded usually by a distinct wall formed of granulation tissue, sometimes partly developed into connective tissue. This frequently forms a definite separable membrane, which separates the abscess from the brain tissue, the latter being often softened in the immediate vicinity. The membrane takes some time to form, being rarely distinct till the third week and not fully formed for two months or even longer. When once formed and encapsuled the abscess may remain long stationary, but it usually enlarges gradually, and may finally burst into the lateral ventricles or on to the surface of the brain.

The abscess causes enlargement of the part affected, and the convolutions over it are flattened and softened. According to Ballance some 40 per cent. of all cases of abscess of the brain are secondary to middle ear disease and are, with few exceptions, located either in the lateral lobe of the cerebellum or less frequently in the temporo-sphenoidal lobe.

3. **Chronic localized encephalitis.**—The processes of chronic inflammation are similar to those in the spinal cord, and the result here, as there, is **Sclerosis**. In the case of the brain there is hardly anything of the systematic sclerosis so frequent in the cord. There is, however, one form of disease which affects both brain and spinal cord, and which presents some analogies with the systematic scleroses of the cord.

Disseminated or Insular sclerosis, Sclerosis in patches.—The causation of this disease is exceedingly obscure. Marie is of opinion that in the vast majority of cases the cause is some form of infection. The frequency with which the disease follows some of the acute infectious diseases, especially typhoid fever, small-pox, and scarlet fever, is in favour of this view. In some cases a history of traumatism is obtainable, but in many no definite cause can be assigned. Syphilis does not seem to play any causative rôle. It mostly comes on without any definite cause being assignable. It is characterized by the occurrence of patches of chronic inflammation or degeneration scattered over the cord, or the brain, or both. These patches have all the characters of sclerosis; in the white substance, where they chiefly occur, they are grey, and in both white and grey substance they produce induration and shrinking. Under the microscope the sclerosed white substance shows loss of the medullary sheaths of the fibres, while the axis cylinders, except in advanced stages, are largely retained. In the grey substance, the ganglion cells are shrunken, sometimes with pigmentation. At the peripheral parts of the patch there may be evidences of more active inflammation, in the form of abundant round cells along with compound granular corpuscles.

The distribution of the patches is somewhat irregular. They are found of various sizes in the cord, medulla oblongata, pons, peduncles, corona radiata, cerebral convolutions, and cerebellum. In such different situations the sclerosis leads to very various functional disturbances. The great frequency of motor tremors, however, suggests some tendency to localization. Erb has pointed out that when tremors exist, patches are specially present on the peduncular parts (pons, medulla, peduncles). If patches are seated there, the motor impulses will be imperfectly conducted but not absolutely interrupted, as the axis cylinders are preserved.

4. **Diffused encephalitis.**—This term may be applied to conditions in which there is a general irritation of the brain, presumably by an irritant circulating in the blood. It may be held to include a considerable number of varied conditions. As the irritant, being in the blood, will attack all parts equally, we may expect to find evidences of irritation in the spinal cord as well as in the brain, but as in other cases of morbid poisons, there will be a selective character.

(*a*) **In Acute febrile diseases** it may be presumed that the brain is irritated by poisons in the blood. According to Popoff, this is evidenced in the case of typhoid fever by the presence of abundant leucocytes. These are stated to be particularly abundant around the vessels, evidently spreading out from these. The leucocytes are frequently found in the spaces around the ganglion cells (pericellular lymph spaces), and even, in some cases, in the substance of the ganglion cells.

Middleton has pointed out that in delirium tremens, tubercular meningitis, uræmia, fracture of the skull with injury to the brain, erysipelas, etc., the brain substance is over-run with leucocytes, the appearances being somewhat similar to those to be described as occurring in hydrophobia. In all cases where irritation of the nervous centres is evidenced during life by **Delirium** or otherwise, these signs of irritation may be looked for in the brain after death. In some cases of erysipelas, diphtheria, and septic inflammations, micrococci have been detected forming centres of irritation with minute softenings.

(*b*) **General paralysis of the insane** (*Dementia paralytica*).—The causation of this disease is obscure, but as it has the general characters of an acute inflammation, followed by a chronic and atrophic stage, it may be supposed that it is due to an irritant of some kind acting on the brain and spinal cord generally.

The earlier periods of the disease are characterized by evidences of abnormal cerebral activity, such as mania, which is sometimes very furious. In this **acute period** the brain is swollen and hyperæmic, and there are multiple foci in which collections of leucocytes and capillary hæmorrhages are visible.

In the **chronic periods**, which most cases have reached before death, the appearances are those of a chronic inflammation of the brain and its membranes, along with degeneration and atrophy of the brain substance. The disease has thus very much the characters of a meningitis and interstitial cerebritis with loss of the proper nervous tissue as a consequence—a cirrhosis of the brain.

The appearances are prominently those of **Atrophy of the brain.** On removing the calvarium the dura mater is commonly found wrinkled and the soft membranes œdematous, evidently from shrinking of the brain substance. The œdema of the membranes is most visible in the sulci, which gape and are filled up with œdematous connective tissue. The fluid is chiefly over the parietal and occipital lobes, perhaps from gravitation. There is also distension of the ventricles, frequently very great, so that the brain substance lying between the fluid in the ventricles and the œdematous membranes is greatly shrunken. The surface of the ventricles is beset with little prominent granulations which are often very marked, especially in the floor of the fourth ventricle, where the appearance has been likened to the tongue of a cat (*langue de chat*). The pia mater is adherent to the surface of the convolutions, so that on attempting to remove it portions of brain substance come away. These adhesions may be taken as indications of the inflammatory nature of the disease, and their locality affords some evidence of the localization of the lesions. Crichton Browne states that they occur mainly in the anterior three-fourths of the brain, affecting the frontal lobe chiefly in its anterior and posterior thirds, and the parietal in all its convolutions.

The brain as a whole is greatly reduced in weight. Taking the normal weight of the brain, including membranes, etc., as fifty ounces for the adult male, and forty-five for the female, the weight in general paralysis often falls to thirty-five ounces. The loss of weight does not affect the brain uniformly; it is mainly the cerebral hemispheres that

are affected, the basal ganglia and peduncular parts being much less so and the cerebellum not at all.

The membranes show irregular thickenings. The **Pia mater** presents milky opacities or more obvious patches of thickening. The **Dura mater** is so frequently affected that at one time it was supposed to be the primary seat of the disease. It presents patches of thickening, opacities, and even flat bony developments, and it is commonly adherent to the calvarium. Not infrequently there are extravasations of blood of smaller or larger size accompanied by appearances to be described afterwards as **Pachymeningitis chronica hæmorrhagica**. The **Calvarium** itself sometimes presents thickening, which is usually diffuse, and may be chiefly due to the shrinking of the brain; sometimes there are also local prominences or actual exostoses. Sometimes the diploë is converted into dense bone, so that the calvarium is much heavier than normal—so-called sclerosis of the bone.

These appearances are due to inflammation and shrinking of the brain substance, the dropsy of the ventricles and œdema of the membranes occurring in order to fill up the space formerly occupied by the brain, the cranium being a cavity of fixed size and the dropsy being *ex vacuo*.

The appearances under the microscope are chiefly those of diffuse sclerosis and atrophy of the brain substance. We have already seen that there is sclerosis of the posterior columns of the cord, and this may even be an early condition. In the brain there are often traces of the earlier acute condition in the form of little clumps of pigment around the vessels, the remains of former extravasations. But the appearances are more those of degeneration. The ganglion cells are shrunken and frequently pigmented; the blood-vessels show sometimes fatty degeneration, sometimes a homogeneous glancing appearance (colloid), and they are frequently obstructed by glancing masses which are partly calcareous and partly colloid. These appearances are not to be regarded as in any way peculiar to this disease, they are simply evidences of the profound atrophy of the brain, and may occur to a limited extent in old persons where there has been only a senile atrophy.

(*c*) **Hydrophobia.**—In this disease the symptoms indicate irritation of certain nerve centres, and a greatly increased reflex irritability. The centres irritated are chiefly those of the medulla oblongata and spinal cord, although delirium, indicating irritation of the cerebral cortex, is also occasionally present. The symptoms point mainly to the medulla oblongata; there are various spasms of the muscles of deglutition and respiration which occur to some extent spontaneously, but are also evoked by slight sensory stimulation. The mere sight of water gives rise to the idea of swallowing it, and brings on a violent spasm of the muscles of deglutition. A breath of cold air on the surface of the body causes a violent respiratory spasm or gasp. The centres in the cord are also irritated, as shown by the tendency to spasm of the muscles generally.

An irritating virus is present in the blood and induces this condition of the nervous system. Pasteur's researches have proved that the virus is present in the cord and medulla. After death manifest signs of irritation are usually visible on microscopic examination. They are to be found most characteristically in the medulla oblongata and next to that in the spinal cord, but are not absent in the other parts of the nervous system. The most prominent condition is an accumulation of leucocytes around the vessels in the substance of the cord and medulla oblongata. There may be just a few leucocytes in the sheath, but from this there are all gradations up to a condition in which the vessel is clothed with a mantle consisting of many layers of leucocytes (Fig. 474). The leucocytes are also present elsewhere, and sometimes in such quantities as to induce some observers to speak of the collec-

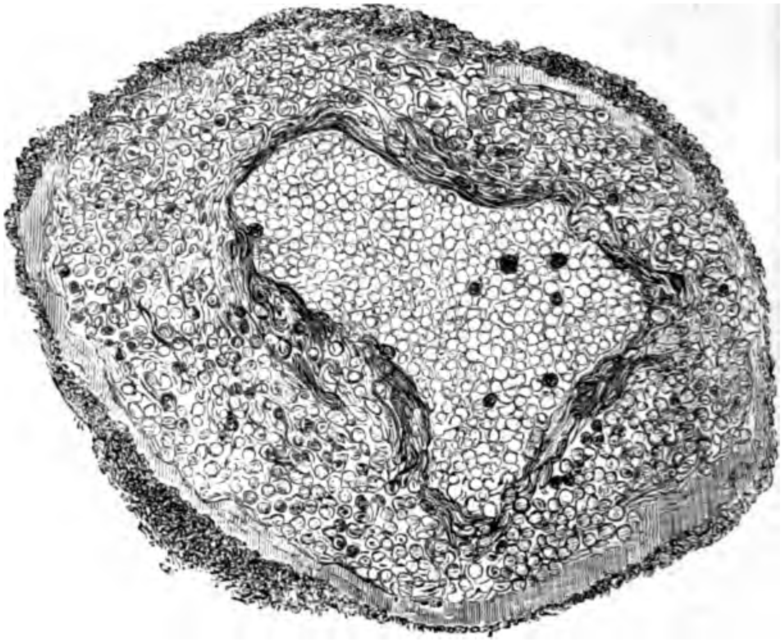

Fig. 474.—A blood-vessel from the medulla oblongata in a case of hydrophobia. Large numbers of leucocytes are seen in its sheath. × 350.

tions as miliary abscesses. The leucocytes find their way into the pericellular spaces and are found keeping company with the ganglion cells in these situations. In the medulla oblongata the main nutrient vessels are towards the posterior part, and as the motor nuclei are in this region, it may be that the localization of the irritation here is partly determined by their proximity. In addition to these conditions minute hæmorrhages have been observed in the medulla and cord.

Signs of irritation are present in other parts of the body besides the nervous system. The salivary glands have been found to present abundant leucocytes between the glandular elements (Fig. 475). In the kidneys also there are signs of irritation in the form of dilatation of vessels and hæmorrhage.

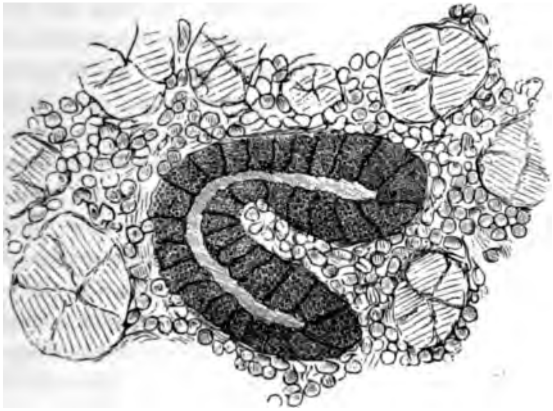

Fig. 475.—From the salivary gland in a case of hydrophobia. In the middle is portion of a duct; abundant leucocytes surround it as well as the glandular structure, shown in outline. × 350.

It is clear then that here an intense irritant, presumably the toxin of a microbe as yet undiscovered, is circulating in the blood, and the intensity of it may be judged from the fact that all these very marked appearances occur within two or three days of the onset of the nervous symptoms. These structural changes vary greatly in degree in different cases, being sometimes very slight. This would indicate that the virus attacks the nerve structures directly, and that the inflammatory appearances are concomitants and not necessary parts of the morbid process.

(*d*) **Tetanus.**—This disease had for long been suspected to be an infective disease by many, but the demonstration and full elucidation of its nature have only been effected within recent years. The **Tetanus bacillus** is a slender rod. Under certain circumstances it produces spores, and these are peculiarly situated at the ends of the rods so that there is the appearance of a **drum-stick.** The spores are very resistant, even to considerable heat. The bacillus is readily stained by the ordinary dyes and also by Gram's method.

The bacillus or spores are present in earth, dust, and sometimes in the fæces of animals. It grows in the ordinary culture media, but is **strictly anærobic.** The cultures present fine brush-like or fir-tree like prolongations. They emit a peculiar odour. In the cultures an extraordinarily virulent **toxin** is produced which shows a very special affinity for the nervous tissues. The symptoms of tetanus may be produced by injection of it free from bacilli. Its nature is not definitely known, but it is destroyed by heat.

The microbe grows locally but produces little local disturbance, at most some hyperæmia but no suppuration. It does not propagate in the blood. The symptoms are produced by the absorption of the toxin into the blood. It is highly pathogenic in the horse and guinea-pig, and in diminishing ratio in the mouse, rabbit, rat, etc. Fowls seem to be immune except to very large doses.

An interesting peculiarity is that pure cultures when washed so as to free them from the toxin are not infective. In order that it may grow in the tissues the microbe requires either some foreign matter which will act on the tissue, such as lactic acid, or the company of some other microbe which will assist it in combating the tissues. In actual cases in man the wound which leads to tetanus contains foreign matter and microbes, and usually suppurates, but not from the action of the tetanus bacillus.

Immunity is produced artificially in animals and the serum of immunized animals contains an antitoxin which protects other animals from the action of the toxin. The symptoms of tetanus are those of an intense irritation of the spinal cord and medulla oblongata. There is violent spasm of the muscles, but those under the control of the medulla oblongata are not so specially involved as in hydrophobia, although the person frequently dies from spasm of the muscles of respiration.

There are signs of irritation discoverable in the spinal cord and medulla oblongata, although they are very different from those in hydrophobia. In tetanus the most prominent and constant appearance suggests the exudation of fluid from the vessels. The fluid sometimes collects around the vessels and, as in hardened specimens the albumen is coagulated, a granular appearance is produced. In other cases it looks as if the fluid produced a disintegration of the neighbouring nervous tissue, the appearance being that of the "granular disintegration" of Lockhart Clarke. The localization of the disintegration around the vessels suggests its origin in an exudation from them. There is also usually an excess of leucocytes around the vessels and in the grey substance of the medulla oblongata generally.

The presence of an irritant as the cause of tetanus was inferred long before the discovery of the microbe, and the disease was in this view grouped along with hydrophobia. In both of these diseases the temperature is elevated, and, especially in the case of tetanus, reaches sometimes a most startling height (110° F.). It is difficult to account for this extreme rise of temperature by the muscular spasm, though the possibility of this explanation is not to be absolutely denied. It seems more probable, however, that the irritant acting to some extent generally on the tissues is the cause of the elevation of temperature. The analogy to the specific fevers is seen in the facts that tetanus has been known to occur in epidemics, and that if a case survives eight days there is considerable probability of recovery, as if the poison ran its course in that period.

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VI.—ATROPHY AND DEGENERATION OF THE BRAIN.

Under the congenital malformations of the brain we have already described several conditions which might be included in the designation congenital atrophy or aplasia. We have also seen that in Dementia paralytica there is an atrophy of the brain as a whole.

Senile atrophy has somewhat similar characters to that last mentioned. Occasionally the brains of old people undergo a general shrinking, and the space is made up partly by dropsy of the ventricles and œdema of the membranes and partly by thickening of the cranial bones. The atrophy is sometimes partial.

Degenerative changes.—It is not necessary to give here a detailed account of these, as they have mostly been incidentally considered.

The **white substance** of the brain undergoes a process of atrophy under various circumstances—in softening of the brain, in sclerosis, etc. It also presents a condition which Lockhart Clarke has designated **Granular disintegration.** This occurs in the neighbourhood of blood vessels, and is probably due to exudation from them. The white substance degenerates into an indefinite granular material.

The **Ganglion cells** are frequently the seat of atrophy and degeneration. They may undergo a **Simple atrophy**, shrinking and losing their processes. But very commonly the atrophy is accompanied by pigmentation, and so a **Pigmentary degeneration** is the result. Virchow was the first to describe a **Calcification** of the ganglion cells. This condition seems to be of frequent occurrence when these cells are suddenly deprived of vitality. It was found by Virchow originally in cases of "*commotio cerebri*," but has since been seen in softening of the brain, in acute anterior poliomyelitis, etc. The ganglion cells having died, and having undergone coagulation-necrosis, become infiltrated with lime, like other dead structures. A **Hyaline** or **Colloid** degeneration of the ganglion cells has also been described, especially in cases of insanity.

Hyaline changes in the vessels of the brain, more especially the arteries and capillaries, are frequent in the insane, more particularly in chronic cases.

Secondary degenerations in the brain.—These are similar to those already described as occurring in the spinal cord, and they concern chiefly the pyramidal tract. This tract degenerates when it is cut off from the motor convolutions at whatever level. This severance is the result of destructive lesions, usually hæmorrhage or softening, the most frequent seat of such lesions being, as already mentioned, the region of the corpus striatum. In cases of extensive destruction of the motor convolutions the secondary degeneration has been traced downwards through the pyramidal tract to end only in the spinal cord. A tract of grey degeneration is found in the parts of the corona radiata corresponding with the lesion. It extends to the internal capsule, occupying the anterior two-thirds of its hinder limb (IK, Fig. 465), thence it passes to the crus cerebri, occupying the middle two-fifths of the crusta, extending from the surface below nearly to the substantia nigra above. In the pons the tract is anterior, and is covered over by transverse fibres which also pass in and separate the bundles. The course in the medulla oblongata and cord has already been traced.

In some cases of unilateral cerebral disease there is a degeneration on *both* sides of the cord, the motor centres of each cerebral hemisphere parently representing both sides of the body. The degeneration, wever, is much more marked in the pyramidal tract on the side posite to the lesion.

Secondary degeneration also occurs in the fibres passing from the rts anterior to the motor area, namely, those in front of the ascending ontal convolution. These fibres pass through the anterior limb of the ternal capsule and the inner part of the crusta of the peduncles, to d in the grey matter of the pons where their degeneration ceases. hese fibres are probably prolonged to the cerebellum, forming communications between the frontal convolutions and the cerebellum ronto-cerebellar fibres).

If of long standing there may be considerable shrinking in the parts ffected by the secondary degeneration.

VII.—TUBERCULOSIS AND SYPHILIS OF THE BRAIN.

Both of these conditions present themselves in the form of tumours, ut more especially tuberculosis. In its clinical aspects, indeed, tuberulosis of the brain substance has all the characters of a tumour, and it onstitutes about half the cases of tumour of the brain.

1. **Tubercular tumour of the brain** (*Scrofulous tubercle of the brain*).—s already indicated, this is a very common lesion, being the most freuent form of tumour of the brain. It is a pure local tuberculosis, and ay occur without any other tubercular manifestation. The symptoms re chiefly those of tumour of the brain, and the diagnosis of the kind f tumour is sometimes difficult.

The tubercular tumour occurs most frequently in young persons, and often multiple. We have seen that tubercles are minute round odies, but here in the brain substance we have solid tumours of a size creasing up to that of a hen's egg and larger (see Fig. 476). These assive tumours are composed of myriads of tubercles, along with the roducts of their degeneration. The greater part of the tumour is ade up of a firm yellow caseous mass, which resembles very closely appearance a scrofulous gland (see Fig. 477). Sometimes the cheesy ass is directly continuous with the brain substance, but usually there a transparent grey zone outside it, and this gradually merges in the rain substance around. This grey zone, when it exists, indicates that he tumour has been growing up till death, and it often contains tubercles f characteristic form. Sometimes there are no rounded tubercles in it, nd it forms simply a cellular zone. The grey tissue gradually merges n the brain substance, and both it and the brain substance show inflamatory conditions characterized by the presence of multitudes of round cells. The solitary tubercles are met with in all parts of the brain and spinal cord, but are most frequent in the cerebellum and pons, and next to that in the cerebrum.

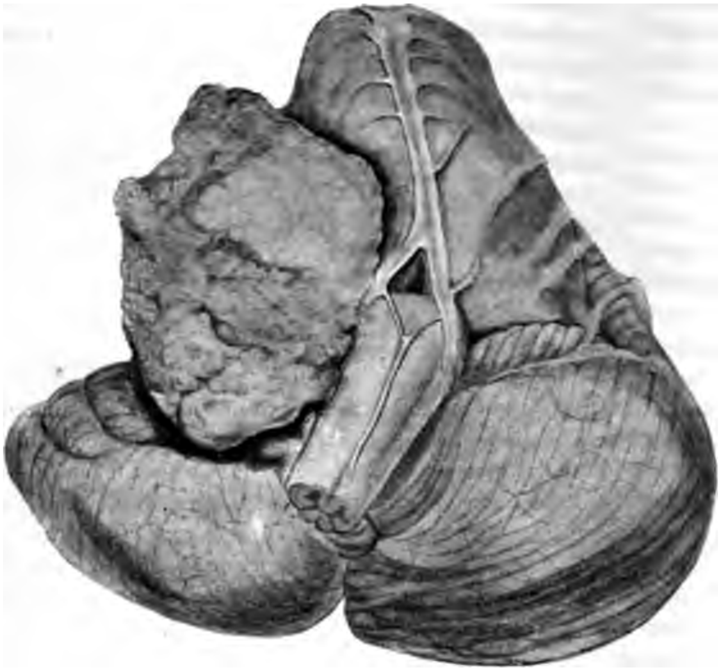

Fig. 476.—Large tubercular growth of the cerebellum exercising pressure on the pons.

The tumours in the cerebrum or cerebellum are almost always near the surface, and they sometimes lead to a local or general tubercular

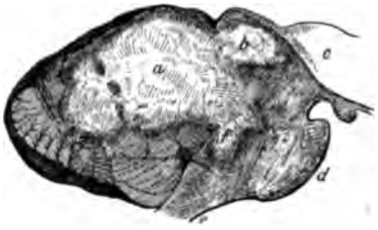

Fig. 477.—Tubercular growth in cerebellum. *a*, Main mass of tumour; *b*, part involving corpora quadrigemina; *f*, part projecting into fourth ventricle; *c*, third ventricle; *d*, pons.

ingitis. In the cerebellum they may be so large as to replace
ubstance of a lobe (see Fig. 477).

2. **Syphilis of the brain and the membranes.**—Syphilis attacks the ain chiefly in conjunction with the membranes. It is very rare to eet with a syphilitic tumour in the brain substance without some nnection with the surface, and probably the lesion, in almost every ase, begins in the membranes (see Fig. 478). The lesions are those of he tertiary stage, and have the characters already described—gummata sociated with more or less inflammation around, and affection of the teries.

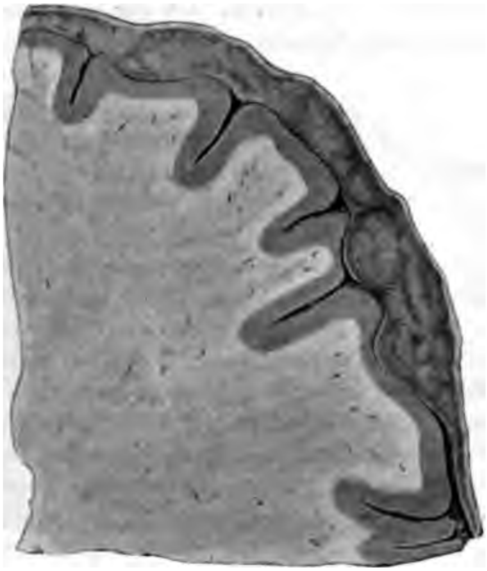

Fig. 478.—Gumma of the membranes of the brain.

The **Gumma** occurs as a grey or yellow mass, or is variously com- sed of both grey and yellow material. The grey structure consists of ore or less fresh granulation tissue, while the yellow is due to caseous crosis, and hence is older. The caseous part consists of granular ructureless matter, in which may be recognized some traces of the iginal tissue, along with fat and blood-pigment. The mass presents ese two constituents in varying abundance (see Fig. 479), and the tline of the tumour is indefinite, shading off on the one hand into flamed and thickened membranes, and on the other into the brain bstance infiltrated with round cells.

Sometimes the gumma obviously grows from the **Soft membranes**— e pia-arachnoid. The membranes are thickened and matted, and herent to the brain beneath. From their under surface rounded masses bulge against the brain substance, adhering to it and causing destruction. There is usually a zone of softening at the advancing margin of the tumour, and there may be considerable areas of softening deeply in the brain substance due to disease of the arteries in connection with the gumma (see below). In other cases the gumma is seated chiefly **in the brain substance**, but it is superficial, and the soft membranes are involved in the process. On the other hand, the **Dura mater** may be the primary seat of the tumour, and here we may have tumours of considerable size—as large as a pigeon's or even a hen's egg. The dura mater is thickened and adherent to the soft membranes, and the tumour is usually to a large extent caseous. These tumours have a special tendency to form in the duplicatures of the dura mater, such as the falx cerebri. The projecting tumours impinge on the brain substance like those of the soft membranes, but they also, when seated over the convexity, project against the bone, producing erosion which may be considerable (*dry caries*).

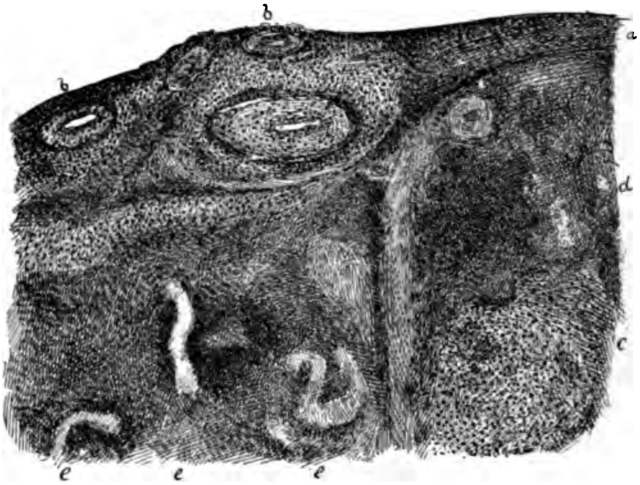

Fig. 479. Gumma of membranes affecting brain. *a*, Thickened membranes adherent to brain ; *b*, *b*, arteries with syphilitic endarteritis ; *c*, *c*, round-celled tissue in brain substance ; *d*, caseous structures, involving occluded capillaries *e*, *e*, *e*.

The gumma may occur at any part of the convexity of the brain, and is also frequent at the base, affecting especially the optic chiasma, pons, and crura. By the latter it may extend to the optic thalamus, but otherwise scarcely attacks the basal ganglia. It not infrequently involves the cerebral nerves as they issue from the brain, especially the optic, and those emerging from the peduncles and pons (third, fourth, and fifth).

It has been already stated that inflammation and thickening of the membranes occur around the gummata, but sometimes a condition exists which may be designated a **Gummatous meningitis.** The gummatous tissue is found more diffusely in the form of a grey gelatinous layer, covering a considerable surface at the base or on the convexity. In the former case there may be some resemblance to tubercular meningitis. In the latter, the whole membranes are thickened and matted together by gummatous tissue, and the brain substance beneath is softened. If, under treatment or otherwise, the proper gummatous tissue disappears, then the thickened membranes may present the appearance of an old simple inflammation.

Syphilitic disease of the blood-vessels, although not confined to those of the brain, is most frequent and most characteristic in them (see p. 183). The lesion is, in many cases, simply a part of the phenomena in connection with a gumma and presents itself in a number of small arteries, as an endarteritis obliterans (see Fig. 479 *b*, *b*). But it also occurs as an isolated affection of the larger cerebral vessels, chiefly those which contribute to the circle of Willis. The appearances are like those of atheroma, but the affection is more localized, occurring mostly in a few patches and not, as in atheroma, extending to a large number of branches. The patches are greyish white and opaque, and the wall is firm, so that the vessel preserves its cylindrical shape. The new-formation has a dense character, and as it consists of the thickened internal coat, the calibre is diminished or even obliterated, especially if thrombosis ensue.

The lesion is a gummatous new-formation in the wall of the artery. It has its seat, according to Heubner, especially between the elastic lamina and the endothelial layer. The new-formation consists of granulation tissue and rudimentary connective tissue in the form of spindle and stellate cells. The lesion is apt to extend some distance along vessels, sometimes involving communicating branches.

An important result of this affection of the arteries is local **Softening of the brain.** This may occur either in relation to a proper gumma, or independently, from the affection of an artery alone. It is due to the narrowing of the calibre and occlusion, and has the same nature as softening from embolism, etc. The softening may be seated at some distance from the gumma or arterial lesion, especially where a long artery is distributed without intervening branches. According to Heubner the lesion affects most frequently the carotid and its branches, especially the middle cerebral, so that we may have softenings in the basal ganglia as in embolism.

The **Functional effect** of these various lesions depends largely on their **Localization.** The gummata and resulting inflammations of the convexity, occurring as they do on the surface, will, at first, irritate the surface of the convolutions. If a motor part be affected then there will be muscular spasm, often progressive and ending perhaps in general convulsions of a quasi-epileptic character. Any sort of local spasm may be produced according to the particular part irritated. If the lesion be over a sensory part there will be subjective sensory impressions. We have already seen that the brain substance commonly becomes involved in the gumma, and that outside it there is also softening of the brain. This destruction of brain substance involves loss of function, namely, motor paralysis or loss of sensation; but there will still be irritation of the marginal parts, and although paralyses and anæsthesiæ may develop, the signs of irritation generally remain prominent. At the base the gumma is very apt to involve motor tracts. The motor fibres of the pons and peduncles are anterior, and are therefore more exposed to the inroads of the tumour. But these paralyses are apt to be complicated by the lesion extending to the cerebral nerves which issue here, mainly the optic, third, fourth, and fifth, and so we have very complex conditions brought about, such as crossed paralysis, etc. Again, the syphilitic disease of the arteries occurs most frequently in the carotid and middle cerebral, and the resulting softening is usually most manifest in the region of the corpus striatum and motor convolutions. In this way a hemiplegia may be produced which imitates that from embolism. It will be seen that a great variety of symptoms may be produced from syphilitic lesions of the brain and its membranes.

Literature.—HEUBNER, Die luetische Erkrankung der Hirnarterien, 1874; GREENFIELD, GOWERS, HUTCHINSON, GOODHART, and others in Path. Trans., xxviii., 1877, pp. 249-360; GREENFIELD, Path. Trans., xxix., 1878; GOWERS, Syphilis of the nervous system, 1892.

VIII.—TUMOURS AND PARASITES OF THE BRAIN.

General effects on the brain.—Tumours are of frequent occurrence in the brain, and produce secondary consequences of great importance. These secondary results are mostly related to the fact that the brain is enclosed in a rigid case, and that either by their own bulk or otherwise the tumours tend to increase the contents of the cranial cavity. Hence there is pressure exercised on the brain. In addition to this there are various destructive effects produced. The secondary effects are, from a practical point of view, the most important consequences of the presence of tumours, and as these effects are, on the whole, similar whatever the nature of the tumour and whether it be primary or secondary, intracranial tumours form a consistent group of lesions. In this view ar and syphilitic tumours are in a similar position to other

re effects are of great importance. Any tumour in its growth
s on the parts in its immediate neighbourhood, and the usual
Softening of the brain substance around, the proper tissue-
being destroyed. When the growth is slow there may be
ssure, and the nerve structures may partly persist around the
If the growth is an infiltrating one like a glioma, the nerve
s may be present in the peripheral parts. Pressure is also
at a distance. The tumour itself by its bulk added to that of
ial contents increases the intra-cranial pressure. The action
ressure will depend somewhat on locality. The dense mem-
septa, the falx and the tentorium, but especially the latter,
action. A tumour of the cerebellum, being confined by the
m, will often cause compression of the parts beneath the latter,
pons is not infrequently damaged by such tumours (Gowers).
umours often lead to **Hydrocephalus**, or accumulation of fluid
entricles, and this raises the general intra-cranial pressure.
urs chiefly when they press on the transverse fissure so as to
veins or lymphatics there (see further on under Hydrocephalus).
ay be considerable thinning of the bones from pressure either
without hydrocephalus, and sometimes even a gap in the
In children the sutures may be widened by the intra-cranial
. The relation of increased pressure to affections of the optic
referred to in the section on Diseases of the Eye.

mation is a common result around a tumour. The irritation
tumour frequently leads to prominent symptoms during life,
presence causes structural changes. The brain substance in
ses shows sclerosis, although softening is more frequent. The
nes on the other hand are usually thickened by chronic inflam-
over the seat of the tumour and even at a distance. In syphilis
mmation of the membranes is very great, and in tuberculosis
sometimes an associated tubercular meningitis.

a.—This form of tumour is peculiar to the nervous system and
uent occurrence there. As its tissue somewhat resembles brain
e in consistence, and as the tumour is an infiltrating one, its
ies are frequently very indefinite and it may even appear as a
local enlargement of the brain. Some cases described as
s of local hypertrophy are of this kind.

ection the tumour generally shows some difference in colour
e brain substance into which it merges at its boundaries. It is
y redder than the white substance, and sometimes deeply red

from excessive development of vessels. There is not infrequently hæmorrhage in the substance of the tumour, and this may be so considerable that the whole softened mass has the appearance of an extravasation of blood, and may be mistaken for this.

In its structure the glioma consists of cells usually round and of small size. These are enclosed in a granular, homogeneous, or finely fibrillated intercellular substance (see Fig. 480), which is usually very soft and delicate. Sometimes the intercellular substance has a distinctly fibrous character, and the tumour is then very firm. Sometimes the intercellular substance has a mucous character, in which case the tumour may be designated a **Myxo-glioma.** On the other hand the tissue may become very cellular and the tumour assume the characters of the sarcoma.

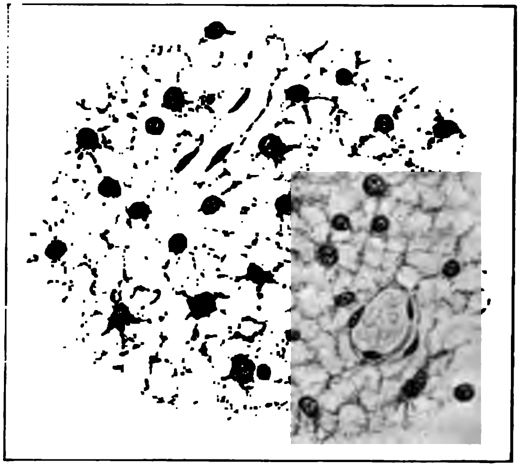

Fig. 480. Glioma of the brain. × 200.

The glioma usually grows slowly. When it reaches the surface there are sometimes defined growths formed, which may be pedunculated. There may be small separate growths formed on the surface (see Fig. 481).

Ziegler describes under the name Neuro-glioma tumours composed not only of neuroglia, but also of ganglion cells and nerve-fibres. Such tumours are due to errors of development, and are congenital. They are better regarded as cases of Heterotopia of the brain substance (see under Malformations of the brain).

The **Psammoma** is not a frequent tumour of the brain substance, being much more common in the choroid plexus and dura mater (see p. 312).

In a case seen by the author, a hard calcareous tumour, which was with difficulty incised, measured $\frac{3}{8}$ by $\frac{1}{4}$ of an inch, and to that extent completely replaced the brain substance. It was seated at the surface of the convolutions. It was composed of the characteristic sand granules held together by a very small quantity of connective tissue. These bodies also occur in other tumours, chiefly sarcomas.

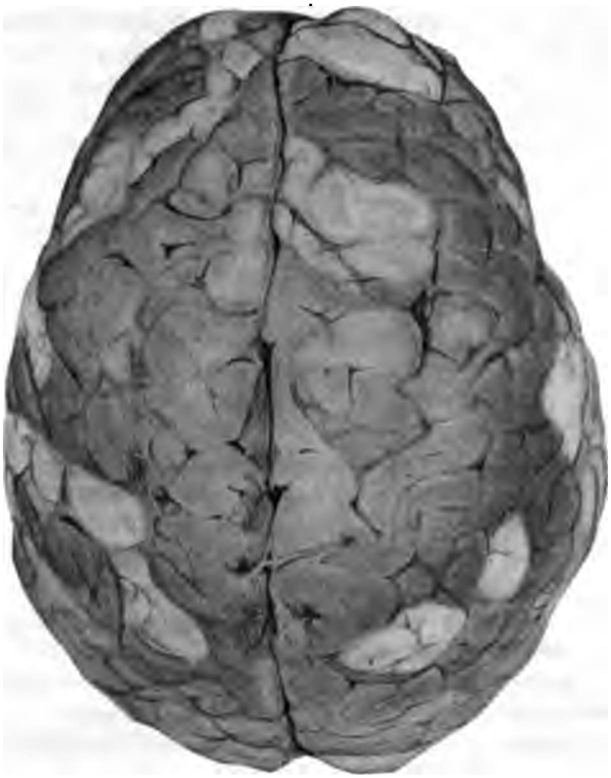

Fig. 481.—Multiple glioma in the brain of a child. The lighter portions represent tumour tissue.

Sarcoma.—The sarcoma of the brain substance is a circumscribed tumour, in this respect contrasting with the glioma (see Fig. 482). It occurs in the midst of the brain substance, and usually in a more or less rounded form, being free to expand in all directions on account of the softness of the tissue around. It sometimes attains a very large size (see Fig. 483). The round-celled sarcoma is the commonest form, but spindle-celled tumours and those with variously shaped cells are not infrequent. The sarcomas vary in consistence, the softer ones being usually round-celled. They may soften in the central parts and form cysts. Most demarcated tumours of the brain, excluding tubercular masses, are sarcomas.

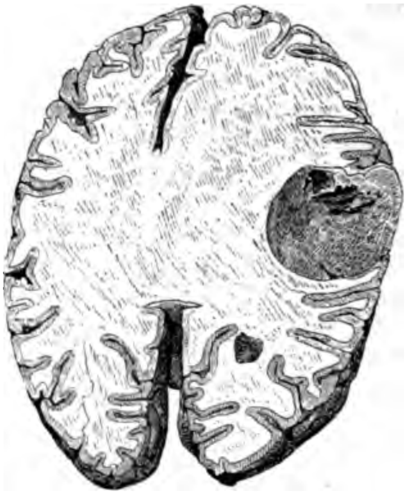

Fig. 482. Spindle-celled sarcoma of brain. It forms a defined tumour. The affected hemisphere is considerably enlarged by its presence.

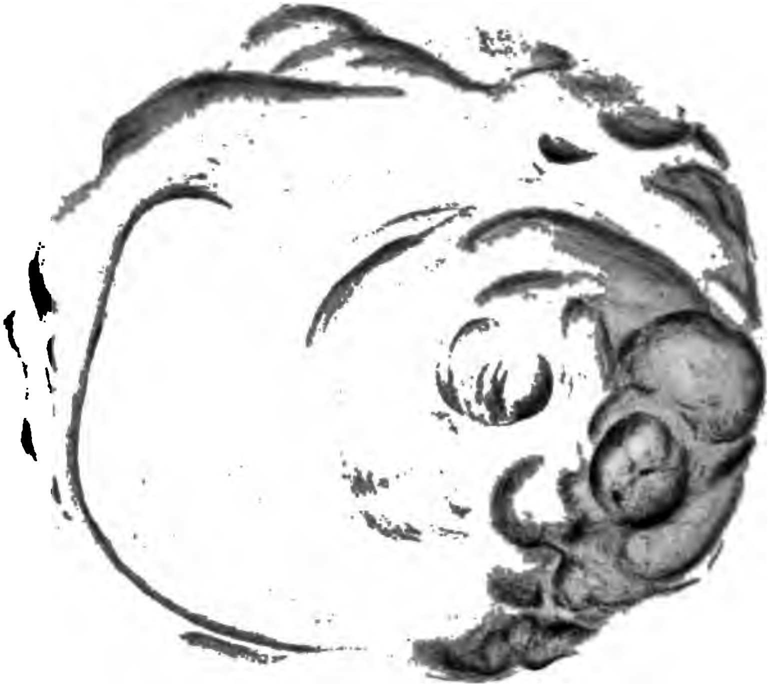

Fig. 483.—Unusually large spindle-celled sarcoma of the brain. Actual size.

Myxoma is not a frequent tumour of the brain. The **Cylindroma** is of occasional occurrence (see p. 343).

Of the other tumours, Osteomas are occasionally seen. Lipomas are very rare. Angioma is also rare.

The **Cholesteatoma or Pearl tumour** is a rare form which occurs chiefly in the membranes, but is also met with in the substance of the brain. It consists of a cyst containing epidermic cells which have a glancing character and are arranged in rounded masses. Cholestearine crystals are often present in large numbers. The tumour has a soapy appearance. It probably originates from the epithelium of the spinal canal or ventricles, and is therefore an epithelioma. Ziegler mentions that small hairs may be present in the tumour.

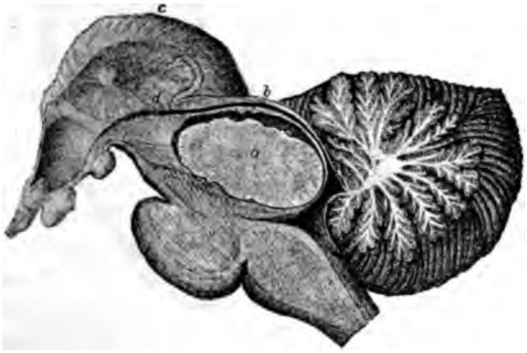

Fig. 484.—Primary cancer of the brain. *a*, Tumour; *b*, corpora quadrigemina stretched over it. The aqueduct of Sylvius is visible between tumour and corpora quadrigemina; the tumour bulges into fourth ventricle. *c*, Thalamus opticus; *d*, third ventricle.

Cancer.—Primary cancer occurs in the substance of the brain, but is perhaps usually connected with one of the ventricles, from which it probably derives its epithelial elements. In the case figured (see Fig. 484) the tumour had its seat chiefly in the fourth ventricle and aqueduct of Sylvius, bulging into these. It consisted of a vascular stroma and cylindrical cells which impinged on the brain substance.

Secondary cancer is not common in the brain. It may form single or multiple tumours. In a case recorded by the author in which the primary tumour was presumably in the lung, the secondary tumours occurred chiefly in the form of **Cysts**, twenty-four of which were discovered in the brain (see Fig. 485). In one of the tumours which was not yet entirely cystic the cancerous structure was apparent (see Fig. 486).

Parasites.—The **Cysticercus cellulosæ**, which is the scolex form of the tænia solium, has occasionally its seat in the brain, usually in the cortical portions, but it may be in any situation. It forms a small round structure enclosed in a connective-tissue capsule. Inside this the proper stratified membrane of the parasite, as well as the head

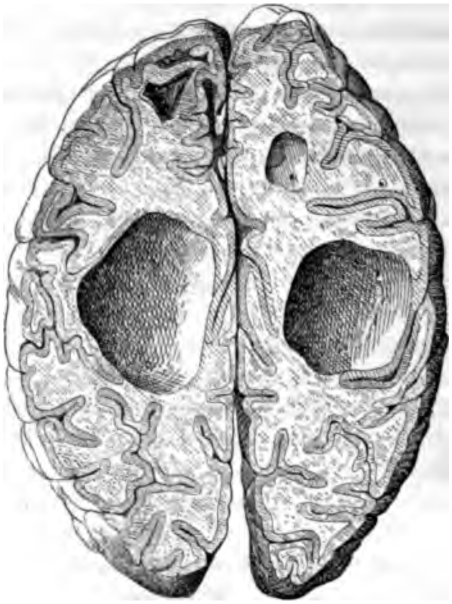

Fig. 485.—Secondary cancer in brain. Cysts developed.

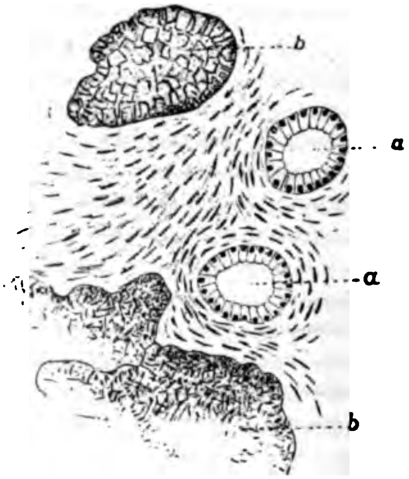

Fig. 486.—Secondary cancer in brain developing cysts. *a, a*, Duct-like canals; *b, b*, larger spaces, the beginnings of cysts.

e Fig. 250, p. 426) and other structures, are found. Some-
ies the parasite is dead and calcified. As a rule it produces little
turbance, and is often found by accident after death. If situated
the peduncular portions it may produce serious symptoms, but
n here its slow growth and small size generally allow of accommo-
ion. Sometimes several cysticerci,—as many as 10 to 20,—have been
und.

The **Echinococcus** more rarely develops in the brain. It forms its
ual cysts, which are generally in the substance of the cerebral hemi-
heres. It also occurs in other parts of the brain, and between the
ra mater and the bone.

Literature.—Gowers, loc. cit., ii., and Syphilis of the nervous system, 1892; Hale
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rious authors and tabulation of 54 tumours, Path. Trans., 1886, xxxvii., pp. 6-89;
ats (Cancer), Path. Trans., 1888, xxxix., p. 5, (Multiple cysts) ibid., p. 326;
pinger (Cholesteatoma), Prag. Vierteljahrschr., 1875; Rokitansky (do.), Hand-
ch, ii.; Müller, Virch. Arch., viii.; Bruns, Die Geschwülste d. Nervensystems,
97.

SECTION IV.—CONTINUED.

D.—THE MEMBRANES AND CAVITIES OF THE BRAIN AND SPINAL CORD.

Introduction. I. **Accumulation of cerebro-spinal fluid.** 1. Œdema of membranes. 2. Hydrocephalus, acquired and congenital. 3. Dropsies of central canal and meninges of cord. (*a*) Hydrorrhachis interna, hydromyelia, syringomyelia. (*b*) Spina bifida, in various forms: the tumour of spina bifida; condition of the cord; spina bifida occulta. II. **Meningeal hæmorrhage.** 1. Hæmatoma of dura mater; 2. Hæmorrhages in soft membranes, especially the infantile form. III. **Inflammations. Meningitis.** 1. Pachymeningitis: 2. Leptomeningitis, including (*a*) simple, acute, and chronic, (*b*) epidemic cerebro-spinal, and (*c*) tubercular meningitis. IV. **Tumours of the meninges.** V. **Affections of the Pineal and Pituitary bodies.**

INTRODUCTION.—The **Dura mater** is a dense connective-tissue membrane which has much more intimate connections with the bones than with the brain and spinal cord; it forms, in fact, a periosteum to the bone. On its internal surface there is no separate arachnoid membrane, but the dura mater is less vascular here than in its external layers. The space between the dura mater and the surface of the brain is sometimes described as a serous cavity analogous to the pleura or peritoneum, but in its pathological relations, at least, it is very different, and it is better designated as the **Subdural space**. The internal surface of the dura mater and the external surface of the arachnoid are defective in vessels, and are hence little liable to inflammations. This cavity forms, in fact, a kind of barrier to the propagation of inflammations either from without or within. Hence inflammations of the external surface of the dura mater seldom extend to its internal surface, and it is very rare to meet with an inflammation affecting the whole subdural space. On the other hand, the **arachnoid and pia mater** really form one membrane, which is partly in two layers. The deep layer or pia is closely connected with the surface of the brain and spinal cord, following the various irregularities of the surface. This deep layer is connected with the superficial one—the arachnoid—more or less intimately. In the sulci between the convolutions there is loose connective tissue with many interstices, constituting the **Subarachnoid space**. But on the summits of the convolutions the two membranes are intimately united. The free surface of the arachnoid is, like that of the dura mater, defective in vessels, and inflammations of the deeper layer scarcely ever extend to this surface. We have thus to distinguish the dura mater connected with the bone, the subdural space, the pia-arachnoid forming the proper meninges of the brain, and the subarachnoid space.

The **Cerebro-spinal fluid** is contained partly in the **ventricles** of the brain and central canal of the spinal cord on the one hand, and partly in the **Subarachnoid space** on the other. The subarachnoid space at the base of the brain and over the spinal cord is specially well-marked. The brain and cord may be said to be submerged in the fluid contained in these spaces, and the brain, more particularly, lies on a kind of "water-bed" formed by the more voluminous spaces at the base filled with the fluid. The amount of cerebro-spinal fluid as a whole is liable to alterations according as the volume of the brain and the fulness of the blood-vessels vary. The distribution of the fluid also varies between the different parts of the system, more particularly between the ventricles and the subarachnoid space. Between these two there are important communications. The pia mater is prolonged into the lateral ventricles through the **transverse fissure**, as the velum interpositum and choroid plexus, thus forming a somewhat free communication. There is also an open communication between the lower part of the fourth ventricle and the subarachnoid space, by the **Foramen of Majendie**. The subarachnoid space and the ventricles of the brain with the central canal of the spinal cord thus form a continuous system of lymph spaces, and the cerebro-spinal fluid circulates in them. In addition to this, the subarachnoid space communicates with lymph spaces around the vessels and ganglion cells, the **Perivascular** and **Periganglionic spaces**. It is important to observe that the subarachnoid space does not communicate with the subdural space.

I.—ACCUMULATION OF THE CEREBRO-SPINAL FLUID IN THE MEMBRANES AND CAVITIES.

It has been already pointed out that the subarachnoid space, with the ventricles and central canal of the spinal cord, forms a single system of lymph spaces which intercommunicate. The lymph or cerebro-spinal fluid in these spaces may accumulate, and so lead to various forms of œdema and dropsy of the brain. In this connection it is to be remembered that the skull is a closed cavity, and any increase in the fluid in these spaces implies a decrease in the quantity of blood in the vessels or of the brain substance itself.

1. **Œdema of the membranes.**—There may be **General œdema** of the membranes and spaces, perhaps including the perivascular spaces in the brain substance. This sometimes takes place in Bright's disease, and may occur along with an œdema of other parts, or develop in a more isolated manner. The pressure of the fluid in this case was supposed by Traube to be the cause of the symptoms usually called uræmic, and in some cases it may contribute to the nervous disturbances of that condition, although it may not be the chief cause.

Then there is an **Œdema ex vacuo.** When the brain shrinks, as it does in **General paralysis**, or in **Senile atrophy**, there is a serious loss of substance. The loss of substance thus produced may be compensated for by thickening of the cranium or by augmentation of the cerebro-spinal fluid. Thickening of the cranium takes place only to a limited extent, and the space is chiefly filled up by fluid. The ventricles dilate (*hydrocephalus*), and the subarachnoid space becomes highly œdematous. It is to be particularly observed that there is seldom any excess of fluid in the subdural space, but that the soft membranes, especially between the atrophied convolutions, are highly œdematous.

2. **Hydrocephalus.**—This term expresses a massive accumulation of fluid inside the skull. The fluid is, in the great majority of cases, in the ventricles, more especially the lateral ventricles, but in certain congenital cases it is in the subdural space. Hence the terms **Internal** and **External hydrocephalus**. The latter condition scarcely can occur unless there is a congenital defect in the formation of the brain, such as perforation, or absence of the corpus callosum, so that the ventricles communicate with the subdural space.

External hydrocephalus is sometimes used as equivalent to œdema of the membranes, but this is an incorrect use of the term, which really expresses a considerable collection in a cavity.

(*a*) **Acquired hydrocephalus.**—Apart from the form *ex vacuo* already considered in the preceding page, hydrocephalus as met with in the adult is mostly related to a definite disturbance of the circulation in the brain. The walls of the ventricles do not probably have much to do with the supply of the cerebro-spinal fluid to the ventricles. The **choroid plexus** which consists of a convolution of arteries, capillaries, veins, and lymphatics, is the chief agent in this function. It is important to note that the arteries reach the plexus by a totally different route from that by which the veins and lymphatics emerge. The arteries are branches of the middle cerebral and reach the plexus near its anterior extremity in the descending cornu of the ventricle. On the other hand the veins of the plexus pass backwards and emerge from the brain through the great transverse fissure. The veins gather themselves together into the **Veins of Galen**, one of which is connected with each lateral ventricle. The two veins of Galen running side by side pass backwards between the corpus callosum and the corpora quadrigemina to open into the straight sinus. It will be observed that from their different anatomical relations the arteries and veins are not liable to be obstructed simultaneously, and that if the arteries remain dilated whilst the veins are obstructed the resulting passive hyperæmia may be aggravated.

Obstruction of the veins of the choroid plexus or of the veins of Galen so as to produce passive hyperæmia seems the principal mode of causation of acquired hydrocephalus. **Rapid accumulation** is brought about mainly by pressure from without, and chiefly by pressure on the veins of Galen. This is especially liable to occur in the case of

ırs of the cerebellum (as in Fig. 487). The cerebellum being l in a space limited by the tentorium above, exercises considerable ıre within this limited space. Whenever it increases in bulk eins of Galen are rendered liable to pressure. **Tumours of the id plexus**, especially in its posterior part, may similarly obstruct eins and induce hydrocephalus. **Thrombosis of the veins of**

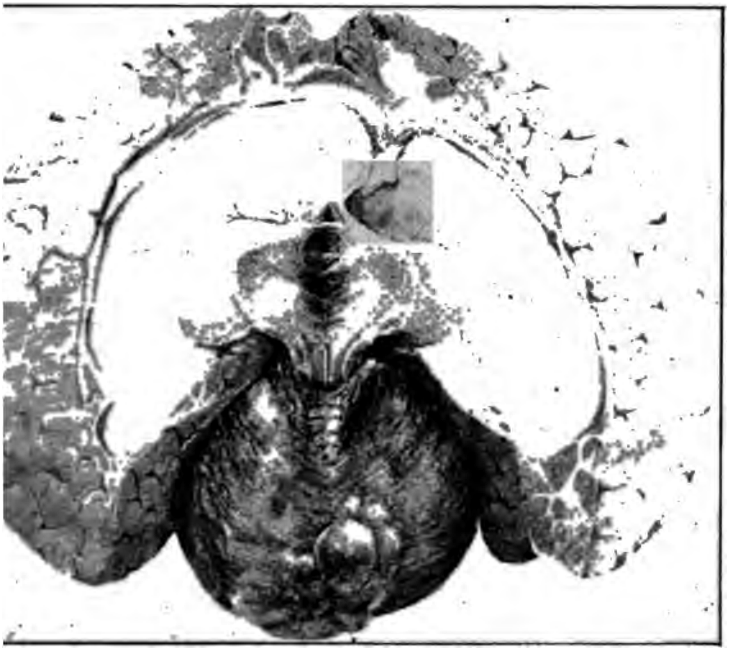

Fig. 487.—Great dilatation of the lateral ventricles (which have been laid open) om tumour of the cerebellum. (From a coloured picture by Dr. A. Macphail.)

is another cause of hydrocephalus but an unusual one. In cases the thrombus originates in the sinuses, and grows into eins of Galen, but Newman has recorded a case in which these alone seemed to be the seat of thrombosis.

Tubercular meningitis hydrocephalus is nearly constant, but it her difficult of explanation. The disease is characterized by an ımatory exudation at the base of the brain, and it might be sed that the fluid accumulated in the ventricles would be inflamy. But, although tubercles are sometimes found on the choroid s, yet the exudation in the ventricles is rarely inflammatory in cter. It consists of a clear pellucid fluid with little albumen, and low specific gravity (about 1010), presenting thus the characters rather of a transudation than an inflammatory exudation. The explanation is probably to be found in part in the exudation outside the ventricles. This is generally abundant where the vellum interpositum emerges from the ventricles in front of the cerebellum, and here, besides filling up the lymph spaces, it is liable to cause pressure on the veins of Galen as they pass through the comparatively narrow isthmus. This is the more likely to produce hyperæmia and exudation from the fact already mentioned, that the arteries reach the plexus by a different route, and are not so liable to pressure.

(*b*) **Chronic hydrocephalus. Congenital hydrocephalus.**—It has been pointed out in a previous section that various malformations affecting the brain and cranium are due to dropsy of the cerebro-spinal canal during early fœtal life. A similar dropsy may occur at later periods of intra-uterine life, or even after birth. The condition may be designated chronic hydrocephalus, which, it will be understood, is often congenital, and may by the enlargement of the head produce serious difficulty in delivery. No proper explanation of the dropsy has been offered. It is said that chronic hydrocephalus often goes along with rickets, and it has been suggested that as a rickety skull is more yielding than a normal one, too little pressure is exercised on the brain, and the accumulation of fluid is allowed. This is not, however, a sufficient explanation, especially of the severe congenital cases. The probability is that the disease depends on a congenital defect in the apparatus for the secretion and absorption of the cerebro-spinal fluid.

The dropsy may be general, affecting all the ventricles, but the fourth is often but little dilated, the fluid being mainly in the lateral and third ventricles. Sometimes the lateral ventricles are alone distended, the foramen of Monro being closed. Sometimes the ventricle of the septum lucidum is obviously distended as it lies between the two lateral ventricles. As the accumulation increases the convolutions are flattened out and they may be completely unfolded, the brain forming a smooth globe over the greatly distended ventricles. The distension may be so great as to cause thinning of the covering brain substance to an extraordinary degree, leaving little between the pia mater and the fluid. The surface of the ventricles (ependyma) is usually somewhat thickened, giving a kind of leathery membranous lining to the cavity, sometimes with granular elevations, especially on the surface of the corpus striatum and fourth ventricle. There may even be rounded prominences consisting of grey brain substance (Virchow). The fluid is clear and pellucid, and has a low specific gravity (1001 to 1009).

With this great dilatation of the ventricles the head is greatly enlarged, and as the bones are more yielding in some parts than others, n alteration in shape occurs. The fontanelles and sutures are widened nd their closure greatly delayed. The frontal bone is pushed forward o that the forehead rises perpendicularly or overhangs the eyebrows; he parietals bulge laterally, and the occipital bones are pushed backwards. The head in this way becomes greatly increased in circumerence, while it is usually much flattened at the vertex. (See Figs. 88 and 489.) The bones of the face, even though they are of normal size, look dwarfed beside the enlarged cranium, and the face has a pinched look. The eyeballs are rendered prominent by the pressure on the roof of the orbit, and enlarged veins are generally een beneath the thin skin of the head.

Although there is this great thinning of the brain substance, it is emarkable how the functions may be retained. A child in this conition may remain very intelligent, and when recovery occurs may pass hrough life with no permanent defect in the functions of the brain; but n the majority of cases there is defective mental development ranging om total idiocy, with perhaps epilepsy, to the lesser degrees of mbecility or of mental enfeeblement. The yielding of the skull seems o prevent any such excess of pressure as to seriously damage the rain, which has a remarkable power of accommodating itself to alteraons in position of its parts. If recovery takes place, the skull to ome extent collapses, the fontanelles and sutures close, often with the ormation of additional centres of ossification, forming Wormian bones n the sutures. But the fontanelles are late in closing, and the cranium etains somewhat of the hydrocephalic shape during life.

In some very rare cases the corpus callosum and its pia-arachnoid have given way, the fluid coming thus to the surface and filling the avity of the dura mater, thus forming a **Hydrocephalus externus**. In hat case the hemispheres are folded aside, and the central parts of he brain are exposed, the brain being as a whole pressed down towards he base. But this can scarcely occur except in congenital cases, and is not consistent with the prolongation of life.

A **Partial dropsy** of the ventricles is of occasional occurrence, either as a congenital or acquired condition. One lateral ventricle may be distended, or even one horn. There may also be a dropsy of the third ventricle alone, or of the ventricle of the septum lucidum. These partial dropsies will cause displacements according to their situation.

3. **Hydrorrhachis interna, Hydromyelia, Syringomyelia, Cysts of the cord.**—Almost all of these affections are congenital in origin. They are related to the central canal of the cord and its development.

The central canal of the cord presents normally considerable variations. In its typical form it is a narrow slit lined with cylindrical epithelium. The tissue immediately around it is much more cellular than the rest of the cord, this bei due to the fact that it consists almost alone of neuroglia without nervous element in this respect comparing with the ependyma of the cerebral ventricles. From th

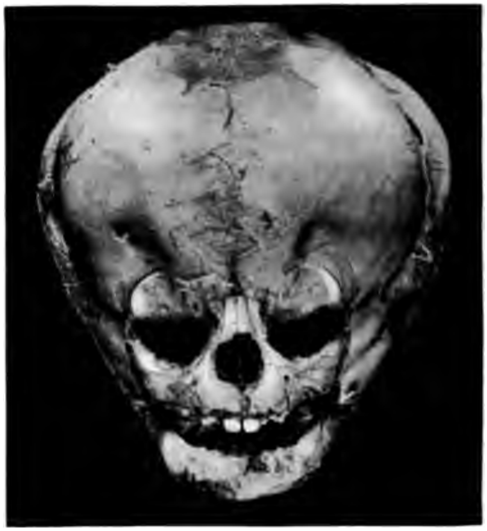

Fig. 488.—Congenital hydrocephalus. Skull of an infant.

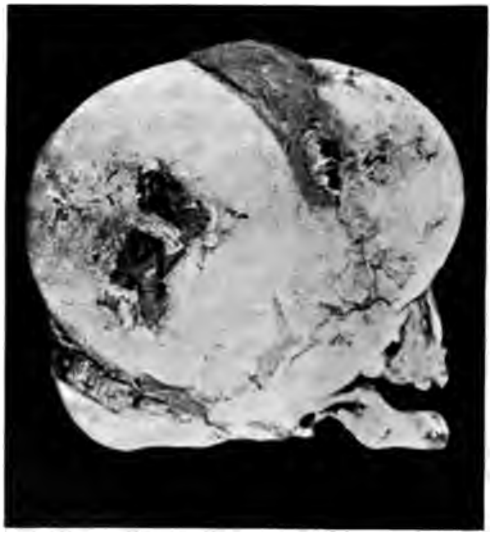

Fig. 489.—Congenital hydrocephalus. From the same case as Fig. 488. Viewed from lateral aspect.

al condition the variations consist in different conditions of the canal itself of the surrounding tissue. The canal may be widened either generally or in ransverse or median direction. On the other hand the canal may be obliterated its position only indicated by the cellular area of neuroglia. These are all in normal limits.

he term **Hydrorrhachis** corresponds with hydrocephalus, and ex- ses a dropsy of the cord, either of the central canal (H. interna) or he meninges (H. externa). Dropsy of the central canal is also gnated **Hydromyelia** and **Syringomyelia**. The former term is lied to cases where the dilatation is obviously congenital, while the er is used where it is met with in the adult. Syringomyelia is, ever, probably always congenital in its origin, so that it may be that it originates in a hydromyelia. These terms are applied to ases of cavities or cysts in the cord filled with serous fluid whether are demonstrably due to dilatation of the central canal or not.

t will be remembered that the central canal is formed by the arching kwards of the medullary plates (see p. 44), so that the closure is terior. The central canal will, there- , at first extend somewhat back- ds, and it is by a gradual coalescence he posterior portions in the middle that the canal takes its usual tion. Dropsy occurring in fœtal life able to cause a permanent enlarge- t backwards as shown in Fig. 490. dilatation may vary greatly at rent levels, so as to lead sometimes to a cystic appearance in the .

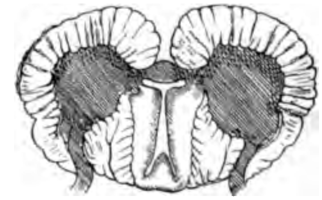
Fig. 490.—Hydromyelia. Enlargement of central canal backwards.

some cases cavities exist in the cord without obvious connection the central canal, but as these are always in the posterior parts of cord, they probably take origin in portions of the original canal, h in the process of coalescence have become isolated. These not quently extend into the posterior cornua, and may be double (Fig. or single (Fig. 492).

n interesting peculiarity of these various conditions is that the us cavities produced are surrounded, like the normal central canal, **neuroglia**, which in some cases is in considerable excess. The ss may be so great as to amount to a tumour (glioma glissis). The ortance of this is emphasized by the occasional co-existence of syrin- yelia with tumour of the cord, and even with multiple tumours (see ers). Gliomata of the cord mostly originate behind the central l, even when there is no dilatation of the latter.

Hydromyelia and syringomyelia do not usually interfere with the function of the cord, but if the dilatation be excessive, or if there is the formation of a tumour, there may be considerable damage.

Hydromyelia and syringomyelia, at least in the lesser degrees, may at times apparently exist without betraying their presence by any symptoms, but in many cases they are associated with a quite distinctive symptomatology. The condition has been recognized anatomically since the time of Brunner (1688), but such cavities were for long looked upon as mere peculiarities and without pathological significance, and it is only since Kahler and Schultze showed that the condition was capable of recognition clinically that it assumed any importance.

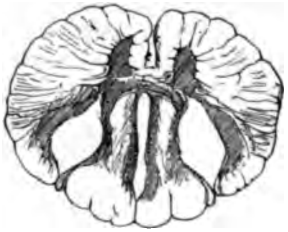

Fig. 491.—Syringomyelia. Cavities in each posterior cornu and in the middle line.

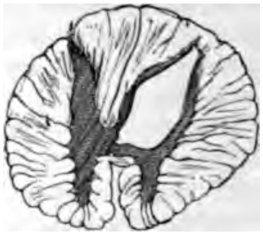

Fig. 492.—Syringomyelia. Cavity in one posterior cornu.

4. **Spina bifida.**—In the section on General Malformations, this condition has already been considered. **Rhachischisis,** or spina bifida without tumour, has been sufficiently described (see p. 51), but the form associated with tumour requires fuller consideration.

The term spina bifida is by some limited to the tumescent form, which is therefore distinguished from rhachischisis, but this distinction cannot be fully maintained.

Spina bifida with tumour.—The tumour forms a rounded swelling, which is usually situated in the lumbo-sacral region, but may be in any part of the column. There is usually a defect in the arches of the vertebræ, and the swelling protrudes posteriorly; but there are a few cases in which the bodies of the vertebræ are defective, and the swelling protrudes into the thorax, abdomen, or pelvis. There is sometimes no defect, or a very slight one, of the arches of the vertebræ, the protrusion passing between two adjacent arches.

The protrusion (Fig. 493) is covered with skin over the greater part of its surface, but in the central part there is often an area of membrane which contains none of the special structures of the skin, such as hairs and sebaceous glands. Inside the skin there are the membranes of the cord; but, according to Recklinghausen, the dura mater is frequently defective to a similar extent with the skin, so that the sac is formed of pia-arachnoid, which is usually considerably thickened. There is generally a dimpling or umbilication at the summit of the tumour (see *g′* in figure), and this sometimes amounts to a small canal which may directly communicate with the central canal of the cord. The umbilication corresponds with an adhesion of the cord to the sac.

The contents of the sac are a pellucid fluid of a specific gravity of about 1007. It is really the cerebro-spinal fluid, and indeed, there is often a hydrocephalus associated with the spina bifida.

Spina bifida implies a dropsy of the structures of the cord, and different names are applied according to the share which the various structures take in the protrusion, these names being constructed on similar principles to those in use for the brain and its membranes. We have (1) *Meningocele*, or protrusion of the membranes only; (2) *Meningo-myelocele*, or protrusion of membranes and cord together; and (3) *Syringo-myelocele*, in which the protrusion obviously consists of a dilated and closed central canal. This form is also called *Myelo-cystocele* (Recklinghausen). Of these three forms the second is much the commonest, although the last-mentioned form is probably more frequent than has been usually supposed (Cleland).

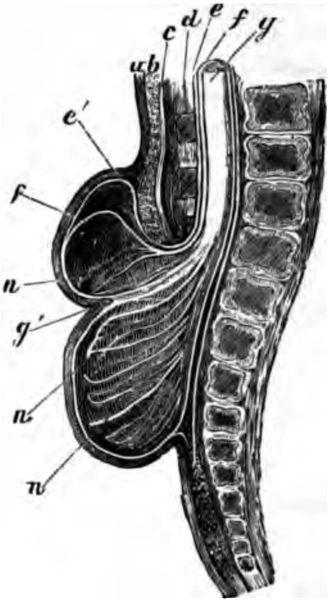

Fig. 493.—Section of a spina bifida of the lumbar region. *a*, *b*, Cutis and subcutaneous tissue; *c*, fascia; *d*, spinous processes; *e*, dura mater, which passes into sac and becomes attached to the skin at *e′*; *f*, arachnoid, which passes into sac forming its internal lining; *g*, spinal cord, which also enters the sac and becomes attached to the skin *g′*, where it had a small opening; the attachment forms a dimple in the sac; *n*, *n*, spinal nerves which pass from the cord round to the anterior aspect of the sac so as to reach their normal places of issue from the spinal canal. (VIRCHOW.)

The Spinal Cord in all forms of spina bifida is **prolonged downwards as far as the seat of the tumour.** As the latter is usually in the lumbo-sacral region, this implies that the cord occupies the entire length of the canal as it does in the earlier periods of fœtal life. As the cord begins to retract within the canal in the fourth month the affection must be earlier in its origin than that period. It is of interest that even in cases of meningocele where the membranes alone are protruded this elongation of the cord occurs.

With the exception of elongation, the cord in a small number of cases is not involved. The fluid may be entirely behind it as in meningocele, and it may be little altered. In that case the nerves also will be in front of the protrusion.

In **Syringo-myelocele** the central canal is distended backwards, and although the internal lining of the sac is really the expanded central canal, yet the sac is, as in meningocele, behind the nerves and the greater part of the cord.

In the majority of cases, however, comprising the **Meningo-myeloceles**, the spinal cord is actually involved in the sac (see Fig. 493), passing into it and attached to its wall, thus presenting various malformations and dislocations. The nerve-roots also which come off from the part of the cord involved take origin within the sac, and traverse it in order to reach their foramina. The posterior roots are necessarily more involved than the anterior. Sometimes the nerves take origin from the posterior wall of the sac, and the latter may present externally a double row of slight depressions corresponding with this origin.

Spina bifida occulta.—This term was first applied by Recklinghausen to an interesting form in which, without a tumour externally, there is elongation of the cord and defect of the vertebral arches. He supposes that there was here an early meningocele, which had subsequently shrunk. An important peculiarity in this form is the existence within the spinal canal, and in contact with the cord, of adipose and fibrous tissue and striated muscle, which may be in such quantity as to form a distinct tumour (myo-fibro-lipoma). The muscle is in bundles like those of the multifidus spinæ, and Recklinghausen supposes that it may have arisen by a dislocation inwards of parts of this muscle through the defectively formed vertebral arches. Another peculiarity is the existence of an **excessive growth of hair** over the concealed spina bifida. It is not improbable that such lesions may be not infrequent. The existence of a tuft of hair in the lumbar region, which sometimes resembles a tail, should call attention to the condition of the arches of the vertebræ, and this may reveal a spina bifida occulta. This form of spina bifida, like that in which a manifest tumour exists, may be associated with lesions of the cord resulting in paralysis.

The origin of spina bifida is to be referred to fœtal life. Looking to the series of forms of lesion from completely open spina bifida with anencephalus to meningocele, it seems necessary to connect the affection with dropsy of the cerebro-spinal canal. A further confirmation of this is the frequent co-existence of hydrocephalus. It can scarcely be supposed that a mere dropsy of the membranes, and still less a simple defect of the arches of the vertebræ, would fix the cord in the fœtal position, so that we are induced to regard the lesion as primarily one of the cord itself. There may be a very early dropsy interfering with the closure of the canal, and so leading to rhachischisis. But after the closure there may be a dropsy leading to a local distension which may subsequently rupture. If it does not rupture then there will be a spina bifida having the form of a syringo-myelocele. If it does rupture then the meningocele or the meningo-myelocele will result. The aperture may be ultimately a very narrow one or may become obliterated, and the central canal may form and even be of normal character. As a general rule, however, the fluid in the sac communicates freely with the cerebro-spinal fluid, and sudden withdrawal of the former sometimes leads to serious cerebral symptoms from the reduction of the cranial contents.

Literature.—*Hydrocephalus*—Leubuscher, Path. d. Hirnkrank., 1854; Huguenin (with full literature) in Ziemssen's Handb., xi., 1; Wilks, Guy's Hosp. Rep., 1860. *Hydrorrhachis, etc.*—Leyden, Virch. Arch., lxviii.; Langhans, ibid., lxxxv.; Krauss, ibid., c.; Schultze, ibid., cii.; Charcot, Leçons du Mardi, 1890; Gowers, Dis. of nerv. syst., ii., latest edition; Hoffmann, Deut. Zeit. f. Nervenheilk., 1892; Schlesinger, Die Syringomyelie, 1897; Isaac Bruhl, Contrib. à l'étude de la syringomyélie. 1890. *Spina bifida*—Förster, Missbildungen, 1865; Virchow, Geschwülste, i. and ii.; Ranke, Jahrb. d. Kinderheilk., xii.; W. Koch, Mittheilungen, 1881; Morton, On spina bifida, 2nd ed., 1887; Cleland, in Morton, p. 32, also Jour. of Anat. and Phys., xvii., 257; Rep. to Clin. Soc. of London, 1885, xviii., 339; Recklinghausen, Virch. Arch., cv., 243 and 374 (with full literature); Bland Sutton, Lancet, 1887 and 1888.

II.—MENINGEAL HÆMORRHAGE.

1. Hæmatoma of the dura mater. Pachymeningitis hæmorrhagica.—Hæmorrhage on the internal surface of the dura mater, a lesion of considerable frequency, is found associated with thickening and new-formation, characters indicative of chronic inflammation. There are differences of opinion as to whether the inflammation is primary or secondary to the hæmorrhage. The lesion presents itself mostly in the form of a somewhat massive blood-clot covering the internal surface of the dura mater and compressing the brain substance. When the clot is more particularly examined it is seen to be not exactly free on the surface of the dura mater, but covered with a delicate membrane, which is continued beyond the clot on the surface of the dura mater as a thin soft layer. This membrane generally has a brownish colour, evidently from the blood colouring-matter, and it presents in its substance, as well as between the membrane and the dura mater, numerous smaller hæmorrhages. This condition is of somewhat frequent occurrence, particularly among the insane.

As indicated above two views are held regarding the nature of this condition, and it is quite possible that there may be actually two diseases. According to Prescott, Hewett, Huguenin, and others, a hæmorrhage into the cavity of the dura mater is the primary condition.

It is undoubted that a hæmorrhage may lead to a condition resembling that described. In a case of aneurysm of one of the larger cerebral vessels, where bleeding had occurred into the subdural space some time before the fatal cerebral hæmorrhage, the author found a layer of soft tissue covering the dura mater and having much of the characters described above. In another case of the author's an injury to the head was followed by a hæmorrhage on the internal surface of the dura mater. The blood-clot was in great part replaced by an organized highly cellular membrane, in which were wide capillaries (see Fig. 494). This case had the further peculiarity (to be referred to further on) that the new-formed membrane became the seat of tuberculosis. In these and similar cases the coagulum on the surface of the dura mater becomes organized in the usual way, and vessels pass from the dura mater into the rudimentary tissue thus produced. These thin-walled vessels (see figure) are specially apt to bleed for reasons to be presently referred to, and so there is hæmorrhage in and under the new-formed tissue.

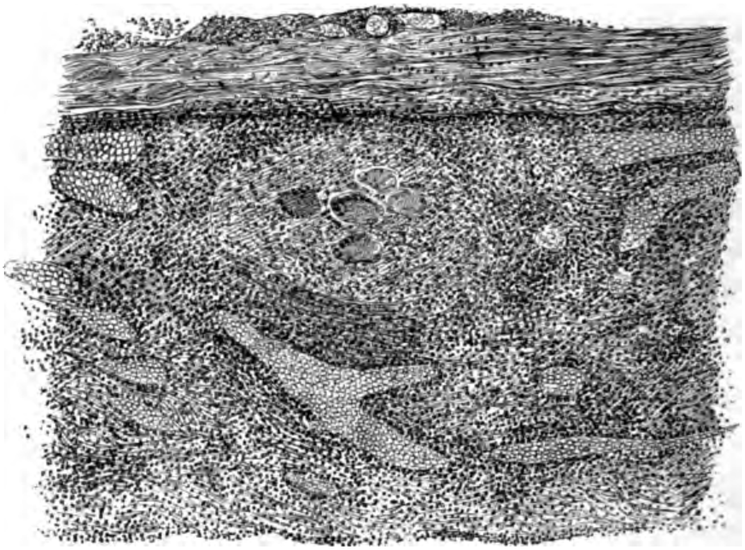

Fig. 494.– Dura mater with organized clot coating its internal surface. Above is the dura mater. The new-formed tissue has wide capillaries, filled with blood-corpuscles. A tubercle with giant-cells is seen in the deeper part of the new-formed tissue.

But many cases have a more spontaneous origin, and agree with the description which Virchow has given of a **Pachymeningitis hæmorrhagica.** This disease begins as an inflammation of the dura mater, aracterized by hyperæmia. The inflammation being chronic, the sult is the formation of a soft membrane on the internal surface of the ra mater, owing to an inflammatory transformation of its internal yer. In its structure this membrane somewhat resembles mucous sue, containing stellate and spindle-shaped cells in a matrix which ves a precipitate with acetic acid. In it there are large thin-walled ood-vessels in large numbers. The false membrane is easily lifted om the dura mater with forceps, and as this is being done numerous d threads are seen to stretch from it to the dura mater; these are e blood-vessels.

An explanation of the large size and tendency to rupture of these vessels has been ggested by Rindfleisch. To begin with, there is hyperæmia of the dura mater th relaxation of the arteries. The normal capillaries of the dura mater being in lense tissue are not readily dilated, although the blood in them is at a high pressure. e new-formed vessels, however, are delicate and lie in a soft tissue, and they mmunicate with the capillaries of the dura mater, in which the blood-pressure is cessive. They are therefore very liable to dilatation, and although they have the ructure of capillaries they are mostly three or four times as wide as ordinary ones. hese vessels often rupture, so that there is frequent hæmorrhage into the soft embrane. But sometimes a more considerable hæmorrhage occurs, and the blood cumulating dissects up the membrane from the dura mater, rupturing fresh ssels as it advances. In this way a large flat clot as thick as the hand may be rmed—the proper hæmatoma. It will be observed that this clot is still covered ith the membrane, and it is quite unusual to find the blood escaping into the vity of the dura mater.

If a fatal hæmorrhage does not occur, the new-formed membrane ndergoes organization in the way of other inflammatory structures. becomes more cellular and finally develops into connective tissue hich coalesces with that of the dura mater. The disease, however, is pt to recur, and a fresh soft layer is formed which goes through the me stages, so that there may be several layers in different stages of ansformation on the surface of the dura mater, the innermost layer ving the characters described above.

This condition occurs chiefly over the convexity of the brain, and is ated to be mainly in the domain of the middle meningeal artery. An ute suppurative inflammation very rarely develops in connection with e hæmatoma.

2. **Hæmorrhages in the soft membranes.**—Most of these are secondy to some other lesion and they are usually of minor consequence. e have seen that aneurysms, although situated in the meninges, ive rise, when they rupture, to cerebral more than to meningeal æmorrhage. There are again numerous small hæmorrhages occasionally anthrax, hæmophilia, scurvy, and ulcerative endocarditis. There

are also hæmorrhages from injuries to the skull, especially when they involve lacerations of the brain. But there is one form which is primary and of considerable importance.

Infantile meningeal hæmorrhage.—In severe and prolonged labours, where the head is much compressed and there is obstruction of the vessels, hæmorrhage sometimes takes place on the surface of the brain. It is important because it may lead to permanent injury to the brain. The hæmorrhage is usually bilateral over the convexity or at the base, and in the former case it occupies chiefly the central region towards the middle line. The brain beneath is sometimes much injured, being lacerated and infiltrated with blood. When at the base, the hæmorrhage is chiefly in the posterior fossa, the blood lying on the pons, medulla, and cerebellum, and generally arising from a laceration of the cerebellum

As the blood is absorbed there may remain a permanent atrophy of the parts which have been injured. There may thus be a depression over the central convolutions which are dwarfed and indurated, and the usual secondary degenerations may ensue.

During life, there may be little that is noteworthy in the child immediately after birth, but as the powers develop it may show motor weakness and rigidity of limbs, along with more or less mental defect. The resulting paralysis may be either hemiplegic or paraplegic in distribution according as the lesion is unilateral or bilateral. There is often considerable improvement as life goes on.

Literature.—*Hæmatoma*—Prescott Hewett, Med. Chir. Trans., 1845; Virchow, Würzb. Verhandl., 1856, vii.; Huguenin, Ziemssen's Handb., xi.; Rindfleisch, Path. histol. (Syd. Soc. transl.), 1873, ii., 302; Coats, Journ. of Path., i., 1893. *Infantile hæmorrhage*—Little, Obstet. Trans., 1862; M'Nutt, Amer. Jour. of Med. Science, 1885; Gowers, Dis. of nerv. syst., ii., latest edition.

III.—MENINGITIS—INFLAMMATIONS OF THE MEMBRANES OF THE BRAIN AND CORD.

1. **Pachymeningitis. Inflammation of the dura mater.**—Excluding the condition already described as connected with hæmatoma, the inflammations of the dura mater are for the most part secondary to affections of the bones or sinuses. In compound fractures of the skull, suppuration may extend to the dura mater, and in some cases to the soft membranes. Caries of the bones may have a similar result. Thrombo-phlebitis of the sinuses, especially in cases of disease of the ear, also gives rise to suppurative inflammation, sometimes associated with gangrene of the dura mater. (See under **Abscess of the Brain.**)

2. **Leptomeningitis. Inflammation of the pia-arachnoid.**—As the rachnoid and pia mater are closely connected and form virtually one embrane, they are always associated in their inflammations. The erm **Meningitis** is commonly used without qualification to express nflammation of the soft membranes, which is much more frequent han that of the dura mater. The nutrient vessels of the brain pass n from the vessels running in the subarachnoid space, and their heaths are direct continuations from the loose tissue of the pia ater. Hence in all forms of inflammation there is liable to be an xtension inwards for a certain distance along the vessels. This is mportant, as serious irritation of the cortical substance of the brain s apt to result.

(*a*) **Simple acute Leptomeningitis.**—This name is applied to non-pecific inflammations of the pia-arachnoid. Some irritant obtains ccess to the membranes, and as it is carried by the circulating cerebropinal fluid the inflammation is usually of a spreading character. The ause is usually traumatic and the irritant is **Septic** in nature; but it ay arise from disease of the bones, especially in ear disease, and in hat case the meningitis may be associated with abscess of the brain. There are cases in which the meningitis has an embolic origin, septic matter being transported in pyæmia or ulcerative endocarditis. It has also been found associated with acute specific fevers, typhoid, scarlet fever, small-pox, and with other acute diseases, especially pneumonia. In a large proportion of cases, the infective agent is the **Diplococcus** of Fraenkel (see under Pneumonia), and this is the case in traumatic as well as in other cases. Other forms have been met with, *e.g.* Diplococcus intracellularis meningitidis, Streptococcus, etc.

In the milder cases there may be simply a serous exudation in the ubarachnoid space, constituting an inflammatory œdema. But in most nstances the case goes on until pus, or pus with fibrine, forms. The irst appearances are visible in the neighbourhood of the veins, in the ulci between the convolutions. Very often there is a white or ellow band visible on either side of the vein, and this consists of ccumulated leucocytes, sometimes with fibrine. As the exudation ncreases the veins become buried in it, and the whole subarachnoid pace becomes filled. The spaces being filled out the pia-arachnoid forms a bulky solid layer which may be separated from the surface of the brain, and may form a mould of the convolutions on its under surface. Under the microscope the membranes on the surface of the brain and in the sulci are seen to be packed with leucocytes, and the inflammation extends, as already noted, in some measure along the perivascular spaces into the superficial part of the brain substance.

Acute leptomeningitis is often a disease of the convexity of the brain (*Vertical meningitis*). It may have its origin as in traumatic cases in a particular locality, and it may here be more intense in its manifestations. Sometimes the arachnoid and dura mater are united by fibrinous exudation in such localities. But the infection generally spreads over the surface of the brain, so that on exposure of the hemispheres it is everywhere visible. The affection does not always confine itself to the convexity, but may extend to the base of the brain. There is not commonly any dilatation of the ventricles (hydrocephalus) in this disease, but the ventricles may contain a yellow semi-purulent fluid. It may be noted that, in accordance with what is stated in the Introduction to this section, the exudation is in the subarachnoid space, not on the free surface of the arachnoid.

In children it is not uncommon to have an acute meningitis originating at the posterior part of the base of the brain (*Posterior-Basic meningitis*).

Simple chronic meningitis of the brain and spinal cord is usually secondary. There are thickenings and adhesions of these membranes in different forms of insanity, in diseases of the bones, in the various scleroses of the cord, especially posterior sclerosis. It may be remembered also that a chronic inflammation of the membranes of the cord is sometimes propagated from the peripheral nerves along their sheaths.

(*b*) **Epidemic cerebro-spinal meningitis.**—This disease, which occurs usually in the form of local epidemics but also in isolated cases, has been grouped along with the acute specific fevers. Like them, it depends on a specific morbid poison. The infective agent has been found in many cases to be the **diplococcus** of Fraenkel, which seems to have as one of its seats of election the membranes of the brain (see above). It is to be noted that pneumonia is not infrequently associated with the form of disease under consideration.

The soft membranes present evidences microscopically of acute inflammation, at first in the form of serous exudation with few leucocytes and red corpuscles. This condition is only seen in cases which have died very early after the onset of the disease, for the exudation soon takes on a purulent character as in simple meningitis. The exudation is here also in the subarachnoid space, and penetrates along the sheaths of the vessels, into the nervous tissue beneath (see Fig. 495). There is very seldom any exudation on the surface of the arachnoid, and the dura mater hardly ever takes part in the disease. The exudation is most marked in the sulci between the convolutions of the cerebral convexity, in the fissure of Sylvius, on the surface of the pons and the upper surface of the cerebellum. It sometimes extends e lateral ventricles. In the spinal cord it is most abundant in mbar region, and is almost confined to the posterior surface, it often surrounds the posterior roots.

disease is fatal in over 50 per cent. of the cases, but when ry occurs it is usually complete. Sometimes, however, there manent damage to the nervous structures, as evidenced by ss, etc.

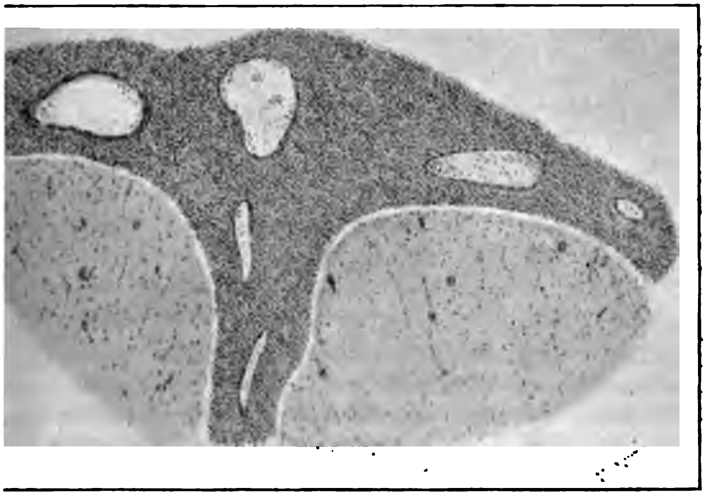

Fig. 495.--From a case of cerebro-spinal meningitis. The soft membranes infil-ated with pus, are seen passing into a sulcus. Dilated vessels are seen in the idst. Vessels are also prominent in the brain substance. × 50.

t from the condition of the meninges and the occasional occurrence of onia the organs of the body show appearances similar to those in other acute The spleen is enlarged but not very greatly so. The follicles of the e are swollen. The liver and kidneys are enlarged and show parenchy- infiltration. There are sometimes abscesses in the muscles and pus in the The skin has a peculiar tendency to show petechiæ during life, and s deeply stained by the blood colouring-matter after death.

Tubercular meningitis (*Basal meningitis, Hydrocephalus acutus*).— disease, as the name implies, depends on the presence in the ges of the tubercle bacillus. The tubercle bacillus is readily ed in the affected structures, more especially in the walls of teries. It reaches the membranes by several different paths, ich three may be more definitely distinguished. In the first the disease is, in many cases, **part of a general tuberculosis,** s associated with the usual lesions in other organs, but the gitis leads to such pronounced symptoms that it often monopolizes the attention of the clinical observer. The primary seat of the affection is frequently in the bronchial, cervical, or mesenteric glands, from which the tuberculosis extends to the veins, and so to the blood. There may, however, be an extension by the blood without the occurrence of a general tuberculosis. The primary seat may be in the lungs, and the extension to the membranes of the brain may be the only secondary extension. In the second place the infection may be derived from a **local tuberculosis of the brain**, which takes the form of a tubercular tumour (see p. 767). When such a lesion originating in the brain substance reaches the surface of the brain, there may be an infection of the membranes with a resulting tubercular meningitis. In the third place a **tuberculosis of the bones** of the skull or vertebral column may extend to the membranes. The tuberculosis is mostly in the basilar portions of the occipital or sphenoid bones, or the bodies of the upper cervical vertebræ. In a case observed by the author, for example, a tuberculosis of the basilar bone and the first cervical vertebra had extended to the pituitary body and thence to the soft membranes.

The meninges are affected by tuberculosis more frequently in children than in adults; it thus seems as if the soft membranes in children were more adapted to the growth of the bacillus. But tubercular meningitis is more frequent in the adult than is usually supposed, and many obscure head cases are found post mortem to be cases of general tuberculosis with, it may be, a very limited meningitis.

The virus reaching the meninges lodges in the lymph spaces of the membranes, and produces inflammation and tubercles in the walls of the finer arteries of the pia mater. These conditions are peculiarly localized in the **basal parts of the brain,** although extending sometimes to the lateral aspects and to the spinal cord. It may be that this is related to the fact that the arteries are distributed from the base, or, more probably, that the cerebro-spinal fluid stagnates here more than elsewhere, and allows of the growth of the microbe.

The **Appearance of the brain post mortem** is as follows. On removing the dura mater, the cerebral hemispheres are generally seen to be fuller than usual, and the surface of the arachnoid is somewhat dry and glazed. This is due to the pressure from the ventricles, which are distended with fluid, usually clear serum. The amount of fluid is sometimes very great, and this prominent feature gave rise to the name **Acute hydrocephalus** applied to this disease (see p. 783). In the neighbourhood of the lateral ventricles, and especially posteriorly, the brain substance is soft and almost diffluent (white softening). On exposing the base of the brain, the appearances of inflammation in the membranes are to be looked for. These are often somewhat obscure, and in appearance trivial. In the slighter cases they consist merely of urbidity or opacity over the pons and optic chiasma. The subarach-id space is occupied by a serous exudation with some pus, which often res it a greenish colour. But usually the exudation is more abundant d covers the basal structures, extending to the surface of the cerebel-m, and up the fissures of Sylvius, where it often reaches the lateral pects of the hemispheres. The concentration of the exudation at the se is of great importance, and the covering-in of the optic chiasma is ten the most significant and sometimes the only prominent sign of the istence of the disease.

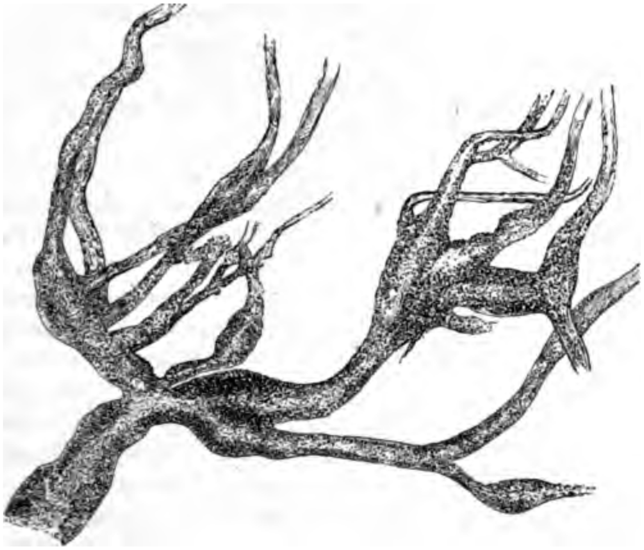

Fig. 496.—Arteries of the pia mater in a case of tubercular meningitis. The frequent spindle-shaped swellings indicate the position of the tubercles. × 16.

The affection usually extends to the **Meninges of the spinal cord,** lthough here it may be even more insignificant in appearance than n the brain. There may be little more than an undue redness with granular appearance on the surface of the cord.

The evidences of inflammation are much more prominent to the aked eye than the tubercles. These are often distinctly visible only n microscopic examination, as they are so much buried in the exuda-on and attached to such small arteries. On opening up the fissure of ylvius, however, where the exudation generally glues the opposed rfaces of the brain together, it is usually possible to see the little hite tubercles, often no larger than pin-heads. If a piece of the soft embrane be removed, however, even from a part where the exudation s very abundant, and examined with a low power under the microscope, the tubercles are readily seen as spindle-shaped prominences on the small arteries (see Fig. 496).

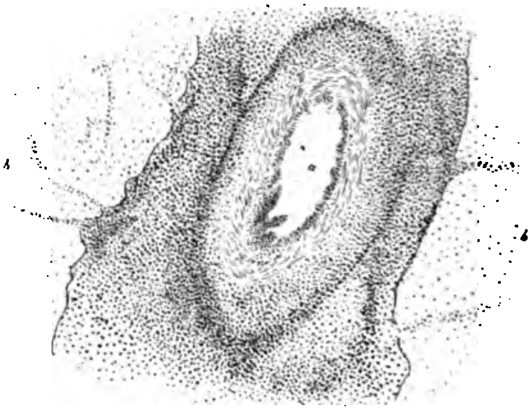

Fig. 497. Tubercular meningitis. *a*, an artery with infiltration chiefly of external coat, but also of internal, which shows villous projections. The connective tissue around is also infiltrated, and so are the walls of the nutrient arteries passing into the brain substance on either side, *b*, *b*. × 30.

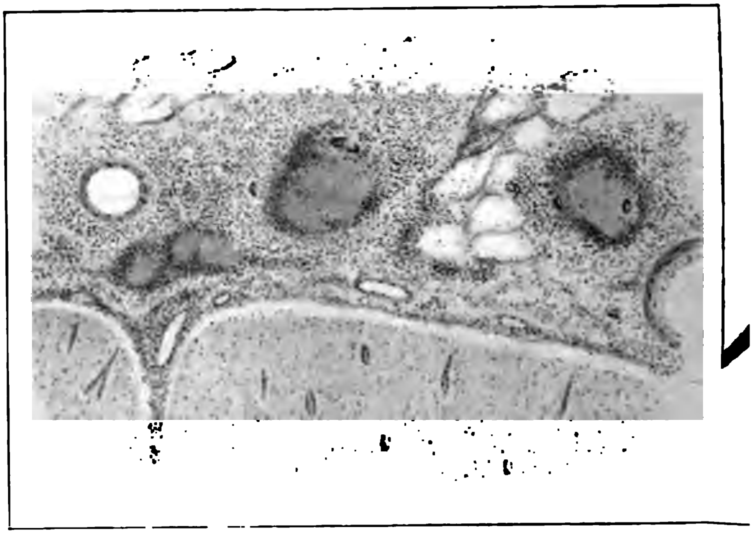

Fig. 498. Tubercular meningitis. Typical tubercles are shown in the exudation. × 50.

There is not, as a rule, in this form of tuberculosis a distinct formation of typical tubercles with giant-cells and epithelioid cells, the nodules described as tubercles being composed of aggregations of round cells. The walls of the arteries are often specially affected, so that they esent localized prominences (see Fig. 496) as if the agent had acted certain spots. The swellings are mainly due to accumulation of cells the adventitia (Fig. 497), but the intima is very commonly also the at of an inflammatory infiltration as shown in the figure. Besides is there are tubercles in the walls of veins and in the tissue apart m the vessels (see Fig. 498), and there is a general infiltration of the embranes with multitudes of leucocytes (see Fig. 497). The inflamatory infiltration extends along the nutrient vessels into the substance the brain and spinal cord, as well as into the cerebral nerves. The perficial parts of the brain substance in particular are hyperæmic, d not infrequently the seat of small hæmorrhages.

Tubercular meningitis like other forms of tuberculosis may undergo aling. This has been asserted on clinical grounds, but has also been nfirmed by post-mortem examination (Fütterer). The membranes e found thickened and contain shrunken and calcified remains of iliary tubercles.

The **white softening** of the parts around the ventricles has given rise to some cussion as to its cause. It may extend somewhat deeply into the brain substance, olving fornix, septum lucidum, corpus callosum, and even the thalamus opticus corpus striatum, and it is sometimes so extreme as to reduce the tissue to the sistence of thick cream. It is clear from the comparative absence of symptoms t this extreme softening does not exist during life. Probably the fluid in the tricles macerates and loosens out the brain tissue without interrupting the tions, and after death a more pronounced softening occurs. The condition is an inflammatory one, and it occurs mainly where the fluid gravitates, namely, he brain substance around the posterior parts of the ventricles.

iterature.—NEISSER, Die Entzünd. der serös. Häute des Geh. u. Rückenm., 1845; UENIN, in Ziemssen's Handb., xi., 1. *Epidemic cerebro-spinal meningitis*—SSNER, Schmidt's Jahrb., 129 and 136; KLEBS, Virch. Arch., xxxiv.; WILLICH eumonia and mening.), Deut. med. Wochenschr., 1875, No. 23; FICKET (ditto), al. de la soc. méd. chir. de Liège, 1880; GOWERS, Dis. of nerv. syst., latest edition erature fully); FREW, Glasg. Med. Jour., 1884, xxii., p. 21; EBERTH, Deut. h. f. klin. Med., xiii.; NAUWERK, ibid., xix.; CORNIL et BABES, Les bactéries, 1886, 446; FLEXNER and BARKER, Amer. Journ. of Med. Sc., 1894; OSLER, Brit. d. Journ., i., 1899; STILL (Posterior-basic), Journ. of Path. and Bact., 1898; es and BARLOW, Allbutt's Syst. of Med., vii., 1899. *Tubercular meningitis*—TTERER, Abriss. der path. Anat., p. 166; HEKTOEN, Journ. Exper. Path., iii., 21.

4. **Syphilitic meningitis.**—This has been described in a previous ge along with Syphilitic lesions of the brain (p. 771).

IV.—TUMOURS AND PARASITES OF THE MENINGES.

Tumours of the membranes of the brain are of importance especially hen they press on the brain or on the nerves as they issue from e skull. They are of considerable variety.

Fibromas have been found arising from the dura mater both of the brain and of the spinal cord. In the latter case they are liable to press on the cord and may even interrupt it. In a case observed by the author a hard fibroma the size of a marble produced serious mischief by pressing on the cervical cord.

The **Chondroma** has occasionally been observed, especially in the dura mater of the cord. In a dog observed by the author, paraplegia was produced by such a tumour in the dorsal region.

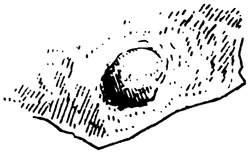

Fig. 499.—A small psammoma of the dura mater, natural size.

The **Lipoma** is a very rare form of tumour in the meninges; that already mentioned on the surface of the corpus callosum (p. 290) probably originated in the pia mater.

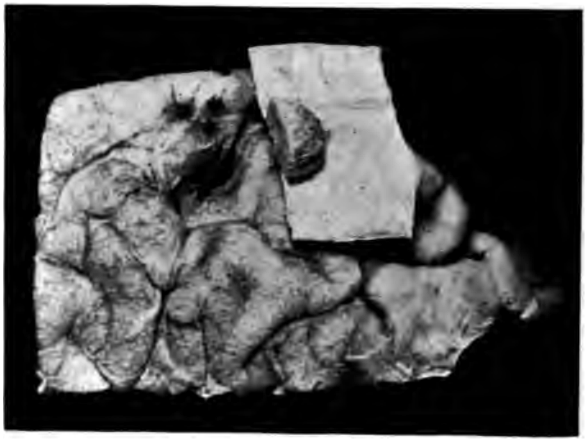

Fig. 500.—Fibro-psammoma of dura mater. Half of the tumour is shown, along with the indentation of the cerebral surface caused by the growth.

The **Psammoma** occurs not infrequently in the dura mater, where it forms a rounded growth on its internal surface (see Figs. 499, 500); sometimes it is multiple. The tumour is usually small, but may be as large as a walnut, and its surface is rough and tuberculated. The psammoma also occurs as a small soft tumour in the choroid plexus and in the pineal gland. In the latter case there may be a tumour of siderable size, whose structure is like that of the normal gland, and the condition is sometimes designated **Hyperplasia of the pineal nd.** There may also be a **Papilloma** arising from the choroid xus either in the lateral ventricles or the fourth ventricle.

The **Osteoma** hardly occurs in the membranes as a distinct tumour, ; it is common to find flat pieces of bone in the dura mater, especially the falx and tentorium, and even in the arachnoid.

The **Pacchionian bodies** sometimes give origin to tumours which may ow to considerable dimensions. These bodies consist of papillæ which ring from the arachnoid and project in various directions; some of em impinge against the skull, where, after thinning the dura mater, ey cause pits; others project into the longitudinal sinus.

Cleland has described two tumours of a papillary character which grew from e dura mater and pressed on the brain substance. Although one of these was uated in the falx, which does not normally present Pacchionian bodies, yet structure of the tumours conformed to that of these bodies. In that on the x there were calcareous masses like those which characterize the psammoma. e tumours measured respectively two inches and one and a half in diameter.

Sarcomas are exceedingly important tumours, especially those **of the ra mater.** Most of them are soft in consistence and contain chiefly und cells. Sometimes there is an alveolar structure, and the cells ve a distinct resemblance to epithelium, so that the tumours have en often described as **Cancers.** There are even tumours remarkably e epitheliomas sometimes observed in the dura mater; they are nerally regarded rather as endotheliomas. The sarcomas generally esent great malignancy. On the one hand, they extend and involve ighbouring parts of the dura mater as well as the soft membranes d the brain; and, on the other hand, they press outwards on the ull, and may, after destroying the bone, work through to the external rface. These tumours have their seat mostly at the base of the skull d often lead to serious nervous lesions. They may involve directly ch structures as the pons or medulla oblongata, the sarcomatous ssue growing into and replacing the proper structure; they also grow to the cranial nerves. By involving the bone and enlarging it, they ay impinge on the foramina by which the nerves take exit. As they e seated usually at the base, they generally, when they work through ie skull, present in the pharynx or nares.

Of the remaining tumours, the **Syphilitic** have been already considered (p. 769). Tubercular growths hardly ever occur except by ropagation from disease of the vertebræ. **Dermoid cysts** of the dura ater have been observed in a few cases.

The **Echinococcus** sometimes develops in the neighbourhood of the spinal canal—in the muscles or in the vertebræ. By enlarging it may extend into the canal, pushing the dura mater before it and compressing the cord. It has even been found to have its seat inside the dura mater. A few cases of **Cysticercus** in the subarachnoid space have been described.

Literature.—Beigel (Cysts of choroid plexus), Path. Trans., 1869, xx.; Kelly (Papilloma of 4th vent.), ibid., 1873, xxiv.; Cleland, Glasg. Med. Jour., xi., 1861; Davaine, Traité des entozoaires, 1878; Mader (Cysticercus in 3rd vent.), Berichte des Rudolfstiftes in Wien, 1872; Gowers and Horsley, Tumour of cord, Trans. Med. Chir. Soc., Lond., lxxi.; Meyerhoff, Die Lipome d. Rückenmarks., Inaug. Diss., 1901.

V.—AFFECTIONS OF THE PINEAL AND PITUITARY BODIES.

1. **Pineal gland.**—The pineal body is a small reddish structure, which is adherent to the under surface of the velum interpositum, so that it is often torn away in removing the choroid plexus and velum interpositum. It is connected by two peduncles of white substance with the optic thalami in front. In the adult the structure of the pineal gland is very indefinite, but it is often partly cystic, and it usually contains calcareous particles, or brain sand.

At an early period of development the pineal gland contains saccules and follicles lined with cylindrical epithelium, and this structure is retained in adult life in some animals. According to some observers the pineal gland is an aborted or rudimentary median eye, the **Pineal eye**, which in the reptilia still shows sufficient structure to be recognizable. The eye is of the invertebrate type having the rods and cones in front of the expansion of the nerve instead of behind it as in the vertebrata. These observations may perhaps explain the occurrence of tumours with epithelium, cartilage, and other structures in the pineal gland.

The gland is occasionally the seat of **tumours**. There are simple enlargements from hyperplasia, sometimes with increase of the brain sand constituting a **psammoma**. There are also **cysts** replacing the gland.

Bulky tumours of **complex structure** have been observed originating in the pineal gland, sometimes attaining to the size of a small apple. Weigert has described a teratoma which measured an inch and three-eighths in diameter, and contained hairs, hair-follicles, sebaceous glands, cartilage, fat, smooth muscle, cylindrical epithelium, and perhaps nerves. The pineal gland is probably the most frequent seat of intracranial teratoma (see Fig. 166, p. 328). Falkson and the author have recorded cases, to which the name chondro-adeno-sarcoma might be given, in which the bulk of the tumour was sarcomatous, but associated with cartilage, glandular structures, and cysts (see Fig. 501); and Turner has described one somewhat similar in structure but without cartilage.

From the position of the pineal gland these tumours are specially ble to distend the third ventricle, and they are also apt to press on optic thalami, peduncles and corpora quadrigemina (see Fig. 502).

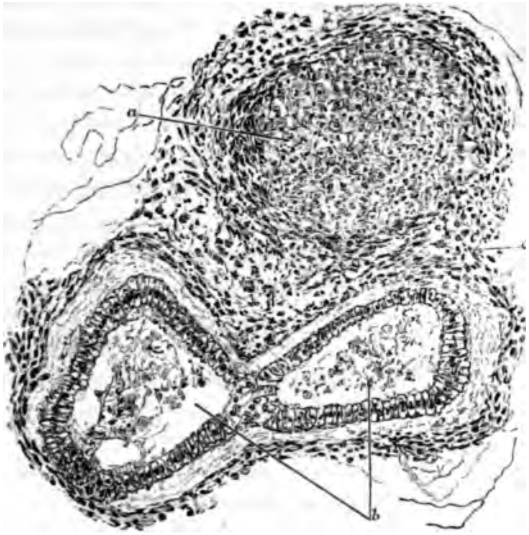

Fig. 501.—From a complex tumour of the pineal gland. *a*, cartilage; *b*, glandular tissue developing cysts; *c*, sarcomatous tissue.

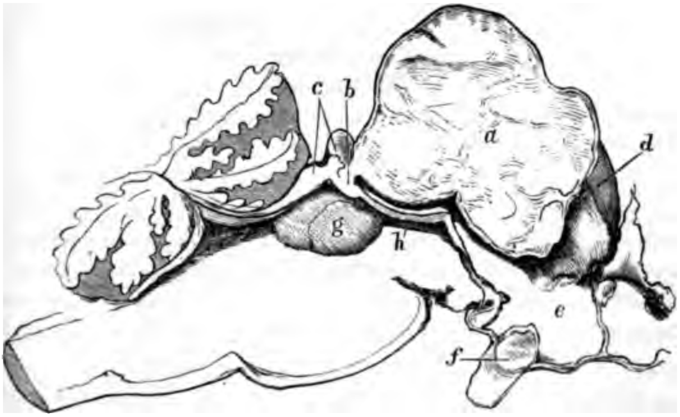

Fig. 502.—Tumour of the pineal gland. *a*, tumour; *b*, pedicle attached in situation of pineal gland; *c*, corpora quadrigemina; *d*, thalamus opticus; *e*, third ventricle; *f*, optic nerve; *g*, portion of tumour in aqueduct of Sylvius and fourth ventricle.

2. **Pituitary body. Hypophysis cerebri.**—The pituitary body or pophysis cerebri is a small body situated in the sella turcica. It is ngated from side to side, and is connected with the brain by a stalk

which is continuous with the infundibulum of the third ventricle. It consists of two lobes, anterior and posterior, with an intermediate boundary layer. The two lobes are very different in structure. The posterior lobe presents chiefly bundles of spindle-shaped cells partly pigmented. The anterior lobe has the structure of a ductless gland, and is regarded as similar in structure and function to the thyroid gland, consisting, like it, of saccules lined with epithelium. In the intermediate zone there are spaces lined with ciliated epithelium.

The analogy between the pituitary body and the thyroid gland has led to observations as to its condition **in diseases of the thyroid**, such as goitre and cretinism, and in cases where the thyroid has been removed. Removal of the thyroid in animals and man is followed by enlargement of the pituitary body, so that it weighs double the amount of the normal body (the normal weight in man is about ·5 or ·6 gramme). The body has also been found enlarged in cases of **myxœdema** and **cretinism**, in which diseases atrophic conditions of the thyroid exist, but it is doubtful if the enlargement is constant. In all these cases it is the glandular anterior lobe which increases in size.

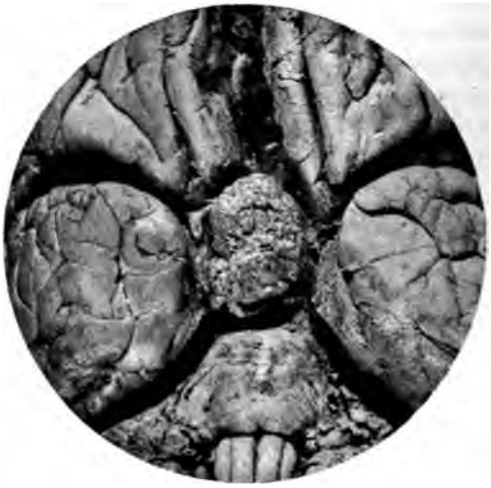

Fig. 503.—Tuberculosis of the pituitary body.

Gummatous lesions have been noted in rare cases. In Fig. 503 is represented a caseous **tuberculous** mass replacing the gland.

Tumours also occur in the pituitary body. Most of the tumours have been connected with the anterior lobe, but a few are recorded in which the infundibulum or posterior lobe has been affected. The ıs of tumours met with correspond with the glandular structure of anterior lobe. **Adenoma**, consisting of a simple enlargement of the ıd, is the form most frequently described. Weigert describes a case which the tumour was as large as a hen's egg. These tumours are .etimes designated by the term **struma pituitaria**, this term again icating a relation to the thyroid gland. **Cysts** which may be serous colloid also occur. **Teratoma** is a rarer form. **Sarcoma** has been t with in some cases (Fig. 504, and Fig. 98, p 238).

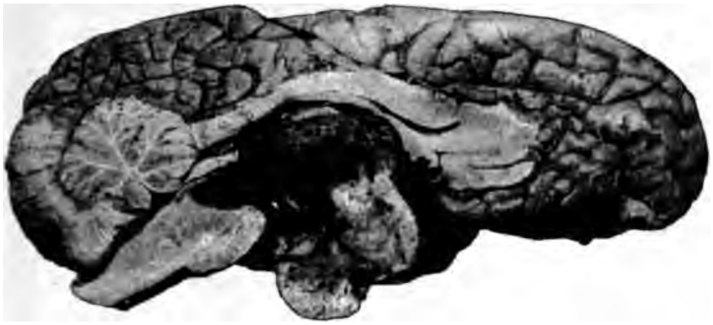

Fig. 504.—Sarcoma of the pituitary body.

t is of great interest that **Acromegaly** is found, in a large proportion ases, to be associated with enlargement of the pituitary body. The argement is glandular and may be cystic, and as large as a hen's ;. There is great enlargement of the sella turcica and deformity of parts around.

iterature.—*Pineal Gland*—WEIGERT, Virch. Arch., 1875, lxv.; FALKSON, ibid., 9, lxxv.; TURNER, Path. Trans., 1885, xxxv.; COATS, ibid., 1887, xxxviii.; IALKOVICS, Centralb. f. d. med. Wiss., 1874; BALDWIN SPENCER (Pineal eye), art. Jour. of microscop. Sc., Oct., 1886. *Pituitary body*—see Literature fully in CE and BEADLES, Journ. of path., i., 378, 1893; WEIGERT, Virch. Arch., lxv., '5; MARIE and SOUZA-LEITE, Essays on Acromegaly, New Syd. Soc., 1891.

SECTION V.

DISEASES OF THE ORGANS OF RESPIRATION.

General Introduction.—The function of respiration implies access of air to the blood and of blood to the air, a double mechanism. Respiratory movements effected by nerve centres. Pulmonary circulation. 1. **Dyspnœa** arises (*a*) from insufficient access of air, and (*b*) from inefficiency of the pulmonary circulation. Compensation of dyspnœa, generally insufficient and liable to fail. 2. **Asphyxia**, the phenomena of sudden suffocation. Ecchymoses in pericardium, pleura, and lungs the most obvious visible results post mortem.

A.—**The Nasal Passages.** 1. Congenital malformations; 2. Hæmorrhage; 3. Acute catarrh; 4. Chronic catarrh; 5. Syphilis and tuberculosis; 6. Rhinoscleroma; 7. Tumours; 8. Foreign bodies.

B.—**Larynx and Trachea.** I. **Malformations.** II. **Inflammations.** 1. Diphtheria; 2. Acute catarrh, sometimes leading to œdema glottidis; 3. Chronic catarrh; 4. Subglottic inflammation; 5. Inflammation of cartilages. III. **Syphilis and Tuberculosis.** IV. **Tumours and Foreign bodies.**

C.—**The Bronchial Tubes. Introduction.** I. **Inflammations.** 1. Bronchial catarrh, constituting ordinary bronchitis, (*a*) acute, (*b*) chronic; 2. Septic bronchitis; 3. Fibrinous bronchitis. II. **Stenosis and Dilatation.** 1. Narrowing; 2. Dilatation; bronchiectasis. III. **Tumours and Foreign bodies.** Importance of the lesions resulting from foreign bodies.

GENERAL INTRODUCTION.

IN studying the different diseases of the respiratory organs it is necessary to consider the effects which they have on the functions of the organs concerned. In this introductory section the structure and function of the organs will be considered together with the alterations in function to which disease gives rise.

The respiratory organs are designed to bring the air into close relation with the blood in order to effect an interchange of gases between the two. With this in view there is a double mechanism by which, on the one hand the air is carried into the lungs, and on the other the blood is propelled into the pulmonary capillaries. Both of these processes are equally necessary to the performance of the respiratory function, and the latter is deranged by interference with either of them.

ie **respiratory organs** proper are concerned primarily in the ssion of air into the lung alveoli or air-vesicles, where it comes close relation with the blood. The air passes through the nose or h, into the larynx, thence down the trachea and bronchi till it ies the lung alveoli, where the essential respiratory surface exists. pulmonary capillaries ramify in a very abundant plexus in the of the lung alveoli, and the blood is separated from the air ly by the capillary wall and a single layer of very thin epithelium. here that the blood gives up its excess of carbonic acid and bs oxygen, the hæmoglobin of the red corpuscles being the um of this interchange. The blood circulates through the capil- with great rapidity, but the interchange of gases occurs in the period occupied by the corpuscles in traversing their respective laries.

ie **respiratory movements**, by which the air is alternately carried the lungs and expelled from them, are effected partly by muscular and partly by elastic recoil. The movements of inspiration are ly muscular, whilst those of expiration are, under normal circum- es, for the most part mechanical, due to the elasticity of the lung e and the natural sinking of the sternum and ribs by their weight elasticity. But even under normal conditions expiration is often ted by muscular effort, as in all forced or rapid expirations. Like uscular movements those of respiration are under the control of iervous system.

ie **respiratory centres** are situated in the medulla oblongata. e centres, removed as they are from the lungs, are influenced in action by the condition of the blood. An excess of carbonic acid deficiency of oxygen in the blood reaching the centres, at once ulates them to increased action. As all muscular actions and other e processes cause a consumption of oxygen and a liberation of nic acid, the amount of these in the blood varies from time to . These varying amounts influence the respiratory centres, so during active exertion, for example, when oxygen is abundantly rbed and carbonic acid given off by the muscles, the respiratory ements are increased in frequency or in depth, or in both. There hus great variations within normal limits. It is important in ion to pathological variations to remember that it is the condition ie blood in regard to its saturation with oxygen and carbonic acid h influences the movements of respiration, and not directly any circumstances in the respiratory organs themselves.

ie **pulmonary circulation** is chiefly dependent on the right ventricle ie heart, whose force propels the blood into the pulmonary artery and on into the capillaries and veins. The respiratory movements also exercise an influence on the circulation. During inspiration, as the capacity of the chest is increased and the intra-thoracic pressure is diminished, the passage of blood into the expanding lungs is facilitated, whilst the passage of the blood from the lungs by the pulmonary veins is hindered. Blood will thus surge into the lungs during inspiration and be partly retained there. On the contrary, during expiration the intra-thoracic pressure is increased and the volume of the lungs diminishes. The blood coming from the right ventricle will by this be partially stayed, whilst the course of that passing onwards to the left auricle will be hastened.

Dyspnœa.—This condition, which means difficulty of breathing, is popularly called shortness of breath. In its physiological aspects it means an **exaggeration of the respiratory movements.** The affected person has the feeling that he does not get sufficient air into his lungs, and there is an actual deficiency of oxygen and an excess of carbonic acid in the blood. There arises, therefore, a stimulation of the respiratory centres by the abnormal condition of the blood, and dyspnœa is brought about when the blood passing to the centres concerned is defective in oxygen or contains an excess of carbonic acid. In dyspnœa the muscles of respiration are called into excessive activity. The muscles which raise the chest and the diaphragm act with exceptional vigour so as to increase the inspiratory effect. There is frequently also a call made for muscular effort to increase the force of the expiratory movements. It is in some cases possible in this way to distinguish the dyspnœa as chiefly **inspiratory** or chiefly **expiratory.**

From the remarks made above, it will appear that dyspnœa may have its origin either in an insufficiency of air reaching the air-vesicles or in an insufficiency of blood passing through the pulmonary capillaries. In either case the blood is insufficiently oxygenated, and the respiratory centres are stimulated to increased action.

Dyspnœa from insufficient access of air is illustrated most directly by obstruction to the air passages. This may be in the larger air tubes or in the smaller. The obstruction may be a mechanical one as by pressure of tumours, or aneurysms, or from accumulation of exudation in the tubes, or it may be due to spasm of the muscular apparatus. The latter occurs somewhat readily at the glottis, which may be closed by contraction of the laryngeal muscles, but it also occurs in the bronchi, where, as in asthma, there may be a general spasm of the finer tubes. But besides the obstruction of the air-tubes, we may have the air prevented from entering the lung alveoli by the latter getting filled up with solid or fluid exudation. This is of frequent occurrence in pneuaonia, in œdema of the lungs, and in tuberculosis of the lungs, and it aay lead to severe dyspnœa.

Dyspnœa from insufficiency of the pulmonary circulation has also arious modes of origin. Thus the vessels may be seriously obstructed y pressure on the lung from without, as in cases where the pleural sac s occupied by fluid or gas in large volume, although in these cases here is also obstruction to the entrance of air. Again there may be reat occlusion of the pulmonary vessels by disease in the lungs themelves. Thus in tuberculosis of the lungs there is great loss of tissue, ncluding the vessels, and in emphysema there is atrophy of tissue and cclusion of vessels. But there is a most important group of cases in vhich, from derangements in the circulation itself and without any lisease of the lungs, an insufficient amount of blood traverses the lung. This mostly arises from disease of the heart, and the form of dyspnœa s hence called **cardiac dyspnœa.** It occurs more especially in disease f the mitral valve, which interferes with the return of blood from the lungs. In this case, the pulmonary capillaries are dilated and may bulge into the alveoli, but the circulation is slow, and there is not sufficient oxygen absorbed to satisfy the tissues. Mere weakness of the heart without organic disease often leads to dyspnœa, especially on xertion.

In most cases of dyspnœa the **organism in some measure accommodates itself** to the altered circumstances, and the dyspnœa is in part t least overcome. This is partly effected by the person limiting the mount of muscular exertion in which he engages, all muscular effort eing accompanied by consumption of oxygen and formation of carbonic cid. Persons liable to dyspnœa learn to go quietly and keep themelves as much as possible at rest. There is also in the case of nsufficiency of the pulmonary circulation a partial compensation ffected by means of the exertions of the right ventricle. By more igorous contractions and ultimately by hypertrophy of its muscular ubstance, the right ventricle succeeds in sending more blood through he diminished channels, or in partly overcoming the impediment at he mitral orifice. These various compensations take place more readily when the cause of the dyspnœa is of **gradual occurrence.** It is a matter of common observation that an interference with the circulation which comes on slowly may produce no perceptible dyspnœa, whilst a similar amount of interference suddenly developed has an exceedingly marked effect.

While the urgency of dyspnœa is frequently overcome, yet the blood is permanently abnormal in respect that the oxygen is deficient and the carbonic acid is in excess. The patient is mostly conscious that dyspnœa is every moment ready to obtrude itself. Any extra exertion, such as climbing a stair or a hill, involving a slight increase in the consumption of oxygen, at once causes a deficiency in the blood, and by stimulation of the medulla oblongata leads to dyspnœa.

There comes a time in most of the chronic diseases that lead to dyspnœa, when even the imperfect compensation described above is no longer possible. This takes place most readily where the dyspnœa is due to interference with the circulation of the blood. As the interference advances the limits of compensation of the right ventricle are reached. The circulation is impeded not only in the lungs, but by dilatation of the right ventricle; and ultimately by insufficiency of the tricuspid valve interference with the general systemic circulation occurs. There is a general venous hyperæmia. With this there is an increase in the entire bulk of the blood, and a further difficulty in keeping up the percentage of oxygen in the increased volume of blood. In such cases the dyspnœa becomes more or less permanent, and there are added to it the phenomena of **cyanosis** and **general œdema**, which are indications of failure in the compensatory power of the heart. These phenomena of dyspnœa and failure of the compensatory power of the heart are not limited to cases of cardiac disease proper, but occur in such conditions as emphysema and bronchitis where the pulmonary circulation is obstructed. They are less likely to occur in cases where from general emaciation the volume of the blood and the bulk of the tissues requiring oxygen are diminished.

The dyspnœa may be increased or rendered more permanent by the occurrence of **pyrexia**. Febrile rise of temperature implying increased oxidation has a similar effect to increased muscular effort in stimulating the respiratory centres. In this connection Cohnheim has called attention to the fact that in pneumonia the occurrence of the crisis with a sudden fall of temperature is usually followed by an almost entire cessation of the dyspnœa, although the air is still shut off from the lung alveoli by the inflammatory exudation as much as it was before.

Asphyxia. Suffocation.—These terms imply a more or less sudden and complete interference with the process of respiration, whether by interruption to the entrance of air into the lungs or to the passage of blood through them. So far as the medulla oblongata is concerned, the effect of a block in the pulmonary circulation will be similar to that of a closure of the larynx or trachea. In either case the blood reaching the respiratory centres will be deficient in oxygen, and the result is an excessive stimulation of these centres.

The first result of a sudden and complete obstruction to the airassages, as when a foreign body gets into the larynx, or in drownng or other modes of suffocation, is the development of **urgent yspnœa**. All the respiratory muscles are brought into violent exerise, but the expiratory phase is more laboured than the inspiratory. hese violent muscular contractions extend to other muscles, and in bout a minute they develop into general convulsions. This is followed y relaxation of the muscles and gradual diminution of the respirations nd death. During the acute period there is a **great rise in the rterial blood-pressure** as measured by the kymograph. In the later eriod the blood-pressure falls to the normal or subnormal.

During the active period of suffocation small **hæmorrhages** or **ecchymoses** occur. These are most common in the lungs and pleura and in the pericardium, but are also met with in certain of the softer issues of the body, as the conjunctiva, pia mater, or retina. Those **in the pleura and pericardium**, as they are the most frequent and most readily observed, afford the most direct evidence post-mortem of death from asphyxia. The most obvious explanation of these hæmorrhages is that they are the result of the excessive increase of the arterial blood-pressure. This is doubtless the explanation of the hæmorrhages in the conjunctiva and pia mater, but in the case of the pleura and pericardium another element enters which acts along with the increased blood-pressure and determines the greater frequency of ecchymosis within the chest. This element is the suction action of the iolent inspiratory efforts producing a partial vacuum in the chest and o diminishing the support of the vessels. It may be stated here that he author is able to state from observations of his own that the hæmorrhages in the chest are not limited to the pleura and pericardium, ut affect the parenchyma of the lung as well. But in the lung the leeding is chiefly in the interlobular connective tissue and not into he lung alveoli. This determines that the hæmorrhage is from the ronchial artery, which supplies the connective tissue of the lung, and not from the pulmonary artery. It is the bronchial artery also which supplies the pulmonary pleura. The influence of the rise in blood-pressure is here seen. The blood in the pulmonary artery does not take part in the rise in pressure, but that in the bronchial arteries does so, as these arteries belong to the systemic system. The pleural and pulmonary ecchymoses are thus due directly to the rise in blood-pressure, but their frequency in these situations is to be referred to the local circumstances of the dyspnœa.

Cohnheim has fallen into the curious error of regarding these hæmorrhages as occurring from the pulmonary arterial system and ignoring the bronchial arteries. As the pulmonary system is not affected by the rise in blood-pressure he infers that the suction of inspiration is the only cause of the hæmorrhages, although admitting that the hæmorrhages in the conjunctiva and pia mater are due to the rise in blood-pressure.

Where the interference with the access of air or with the pulmonary circulation is less sudden or less complete, the phenomena are much less urgent than those above noted, and are of the character rather of those of dyspnœa as already described.

A.—THE NASAL PASSAGES.

1. **Congenital malformations.**—Such deformities as absence of the nose and its cavities, and stenosis, are usually parts of a general malformation, chiefly Cyclopia (see p. 49). In **Clefts of the lip and palate**, the nasal cavities are in communication to a greater or less extent with the mouth. This communication renders the mucous membrane of the nares liable to inflammation. Normally, the nasal passages are protected against any irritation except that of the air passing through them, and the mucous membrane is correspondingly sensitive. We know how the accidental passage of a piece of solid food into the nares causes great irritation, and we shall afterwards see that the existence of a foreign body in the nares is a frequent cause of prolonged catarrh. In cases of cleft palate the food and secretions of the mouth readily pass into the nares, and although a certain tolerance may be established, persons so affected are peculiarly liable to catarrh of the nares.

2. **Hæmorrhage. Epistaxis.**—Hæmorrhage from the nares is of frequent occurrence. There are persons who have a special proclivity to it, in whom it occurs at intervals without apparent cause. It also occurs in consequence of tumours, especially polypi in the nares, the mucous membrane over the tumour being liable to bleed. It is of frequent occurrence in certain forms of cardiac disease, and is an occasional concomitant of fevers (typhoid fever) especially at their onset. The blood usually comes from the anterior part of the nares, and especially from the mucous membrane over the cartilaginous septum.

3. **Acute catarrh. Acute rhinitis. Coryza.**—Acute inflammation of the nares occurs most frequently as a catarrh, constituting the ordinary cold in the head, but there may be a more intense and specific inflammation as in diphtheria and scarlet fever.

In the case of the specific fevers, the special irritant concerned in their production may attack the nares and produce acute inflammation there. This is nearly always the case in measles, but sometimes also in small-pox, diphtheria, and scarlet fever. For ordinary catarrhs Cold is usually assigned as the cause. The mucous membranes of the air passages are indeed much more liable to inflammations than those of he alimentary canal, and an exposure to cold air which would not produce any catarrh of the mouth might possibly do so in the nares. Moreover, the fact that the nares are the nearest part of the air passages to the air, and are therefore most exposed to the action of cold, is an indication that such exposure has probably something to do with it.

Mere inhalation of cold air is not enough to produce catarrh, as every one who is liable to cold in the head will admit. A person is able at one time to brave any amount of exposure without the risk of catarrh, while at another time a slight draught, or no perceptible exposure at all, will bring it on. Such circumstances as these, taken along with the fact that the catarrh has a definite course, usually of a week's duration, justify the view that the disease is really due to a specific morbid poison. In this view it is necessary to suppose that the microbes are usually present in the air or in the mucous membrane, and that they take, as it were, advantage of the mucous membrane when, at any time, it is in a specially predisposed state. This predisposition may be induced by cold applied either directly to the mucous membrane or to some other part of the body, but other predisposing causes may exist. For instance, when a person is overheated the arteries of the skin and of the respiratory mucous membranes are relaxed, and there is an active hyperæmia. At such a time a catarrh is readily induced, apparently because the mucous membrane is less able than usual to resist the action of irritants. There is apparent confirmation of such a view as this in the fact that nasal catarrh undoubtedly occurs as the result of the action of specific irritants. In measles the catarrh of the nares and conjunctiva is referable to the specific virus of that disease. n hay asthma the irritation of the pollen, etc., is the cause of the catarrh. Again, t is commonly stated that nasal catarrh is communicable from person to person, and it is hardly conceivable that this could occur unless the disease had, as a part of its cause, some specific *materies morbi.*

The catarrh begins with an inflammatory hyperæmia of the mucous membrane. This may, of itself, lead to swelling so great as partially to obstruct the passages, giving the feeling of a "stuffed nose." The inflammation soon passes on to exudation. This finds its way for the most part to the surface, but in its passage it increases the swelling of the mucous membrane. The exudation is the usual one of inflammation, namely the blood-plasma with leucocytes. At first this is mixed with mucus, but as it increases in amount it rapidly assumes a serous character, and we know that a great abundance of serous fluid may be discharged from the nostrils. As time goes on the leucocytes increase in the exudation, and it may assume a semi-purulent character. Sometimes red corpuscles are present, and the discharge has a greenish-yellow colour.

It is to be remembered that there are various cavities in direct communication with the nares, of which the principal are the **Frontal**

sinuses and the **Antrum of Highmore**, and that these frequently take part in the acute catarrh. It will be observed that in all stages of the catarrh there is more or less swelling of the mucous membrane, and that this leads to the obstruction of the passages which is such a marked symptom. This swelling is temporary in the acute disease, but in chronic catarrh it is apt to give way to a more permanent thickening.

Acute inflammation sometimes extends to the nares in **Diphtheria**. The anatomical changes will be considered in next section.

4. **Chronic nasal catarrh.**—This may supervene upon acute catarrh, or it may be of more independent origin. **The presence of foreign bodies** not infrequently leads to an inveterate discharge from the nares, more especially in children. The prolonged existence of catarrh leads to various changes in the mucous membrane. There may be **Atrophy** with induration, a process similar to cirrhosis. In this case there is frequently an excessive purulent discharge (**Ozæna**), which usually has a very fœtid odour. In other cases there is **Hypertrophy** of the mucous membrane, which may even amount to a distinct polypus (see below). The finer ramifications of the olfactory nerves are injured by these tissue changes, and smell is lost or impaired, in many cases permanently.

5. **Syphilitic and Tubercular lesions of the nares.**—**Syphilis** not infrequently affects the nares in the tertiary stage. There is the formation of gummatous tissue with inflammation, beginning either in the mucous membrane or in the deeper parts. As the lesion is superficial there is usually ulceration, and this may involve the soft parts and the bones very extensively. There may arise in this way serious lesions, such as perforation of the septum, communication with the mouth, falling in of the nasal bones, etc. When the bones are affected the discharge is liable to be very putrid (*Syphilitic ozœna*). If healing occurs the cicatricial contraction may produce still further deformities.

Tuberculosis of the nares is not often observed, perhaps because the nares are not usually examined fully post mortem. Where the nares have been systematically examined, however, as by Dmochowski, tuberculosis is found in a considerable proportion of cases as a secondary result of tuberculosis elsewhere (21 times in 64 cases). The disease occurs chiefly in connection with tuberculosis of the lungs and larynx. The lesion presents itself either in the form of a more or less localized infiltration or of an ulcer, or the two conditions may coexist. The cartilaginous septum is perhaps the most frequent seat of tuberculous ulceration in the nose. The ulceration may sometimes result in the perforation of the septum. Lupus of the face not infrequently extends the nasal mucous membrane. There are tubercles in the mucous embrane and ulceration.

6. **Rhinoscleroma.**—This is a disease very rarely seen in this country. occurs mainly in the south-east of Europe and appears to be comratively common in Austria.

It originates not infrequently at the margin of the nostril, extending ckwards into the nares or to the upper lip. It may originate in the rynx, pharynx or hard palate. It usually runs a very chronic course.

Slightly elevated nodules or plates of almost cartilaginous consistence evelop in the situations indicated. The lesions are usually smooth on e surface, have a reddish colour and rarely lead to ulceration or ischarge. In the later stages of the disease marked deformity and enoses may result. Examined microscopically the appearances are ose seen in infective granulomata. In addition to the round-celled filtration, larger cells of translucent appearance are found. These ntain, often in large numbers, bacilli which closely resemble the acillus of Friedländer.

7. **Tumours.**—Amongst the lesions just bordering on tumours may mentioned the so-called **Post-nasal adenoid growths.** This name a somewhat unfortunate one, and it should be remembered that the ands concerned are lymphatic follicles and not proper epithelial lands. The subject will be more fully considered in connection with e tonsils and naso-pharynx, which are liable to similar lesions.

Another form of lesion which has affinities with chronic inflammation the **Mucous polypus** of the nares. Like other mucous polypi they ccur very commonly as a result of chronic catarrh, but they appear ccasionally without any apparent cause. They are usually in the form f rounded projections having a comparatively narrow base or neck, e growth becoming more pedunculated as it enlarges. They often oduce much obstruction of the passages, and are not infrequently ultiple. In structure some of them present simply the constituents of e inflamed mucous membrane—connective tissue with rather wide ous spaces, and covered with cylindrical ciliated epithelium. (If the ithelium be examined in fluid immediately after removal, the ciliary tion will be seen.) The connective tissue is usually so infiltrated h serous fluid as to give an œdematous appearance to the polypus, d sometimes a more definite cystic formation occurs. In some cases re are contained in the tumour mucous glands, but it is doubtful if re is a true new-formation of gland tissue. Cysts sometimes develop m dilatation of mucous glands contained in the tumour.

Polypi are sometimes found of a different character from those ntioned above. There may be true **Papillomata**, or there may be

Myxomata or **Fibromata** taking the form of polypi. These latter usually take origin in the periosteum. **Cysts** are rare, if one excludes those arising from polypi. They are usually situated on the floor of the nose anteriorly. Malignant tumours sometimes assume the polypoid form.

Of the malignant tumours, **Sarcomas**, originating mostly in the periosteum or perichondrium, may produce serious obstruction and deformities of the nasal structures. The sarcomas often dislocate the nasal bones, and involve the neighbouring structures in their substance. In this way they sometimes penetrate into the antrum, or involve the hard palate and alveoli. **Cancers** rarely occur in the nares as primary tumours, but may involve them by extension from neighbouring parts.

8. **Foreign bodies.**—Different kinds of foreign bodies are not infrequently found in the nares. They may be introduced into the nostrils accidentally or designedly by children. These may become coated with lime salts so as to form nasal calculi or **Rhinoliths**, which may also form without the presence of a true foreign body, the lime being deposited in inspissated secretions. Occasionally, maggots find their way into the nares, and sometimes fungi (Aspergillus fumigatus) occur.

Most foreign bodies irritate the mucous membrane, producing chronic catarrh, frequently accompanied by very putrid discharges (Ozæna).

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B.—THE LARYNX AND TRACHEA.

The lesions of the larynx and trachea are frequently associated with those of the bronchi, more especially the inflammations. Their separation here is consequently somewhat artificial.

I. **Malformations.**—Entire **Absence** of the larynx and trachea occurs only in acephalic monsters which are incapable of living. There are, further, cases of **Communication between the trachea and œsophagus.** In these cases the pharynx generally ends in a cul-de-sac, and the œsophagus opens into the trachea. Then we meet with cases of imperfect closure of the original branchial clefts leading to the **Congenital fistula of the neck**, already considered (see p. 53). Again, **Individual cartilages**, as the epiglottis, or one or more of the rings of the trachea, may

be absent, or there may be one or more supernumerary rings. The trachea may divide into three main bronchi instead of two, and in that case two stems pass to the right lung and one to the left. Occasionally the larynx is **congenitally narrow**, or it may fail to undergo the usual changes at puberty, especially in cases of castration before puberty or of non-descent of the testes. Lastly, the trachea has been observed to the left of the œsophagus or even behind it.

II. **Spasm of the glottis. Laryngismus stridulus.**—The larynx being exceedingly sensitive, is somewhat readily brought into a state of spasm. Thus the mere introduction of a brush with a stimulating solution into the larynx usually produces a spasm which may be sufficient almost to close the glottis for some seconds. A foreign body which has lodged in the larynx usually produces violent spasm, and the obstruction in these cases may be much more the result of spasm than of the foreign body. Spasm is also produced in some cases by inflammations of the larynx.

Irritation of the nerves of the larynx or of the trachea sometimes leads to spasm of the glottis. Aneurysms by causing irritation of the recurrent laryngeal nerve may produce this effect, but they may do so by pressure directly on the trachea, the effect in this latter case being reflex.

A more independent spasm of the glottis is of somewhat frequent occurrence in children, and is known by the name of **Laryngismus stridulus** or **False croup**. There may be no appreciable disease of the larynx, or at most a catarrh, but a sudden spasm occurs with great distress and urgent dyspnœa. The obstruction may be even fatal. The dyspnœa is accompanied by the crowing respiratory sound and hoarse cough which have given rise to the name Croup.

III. **Inflammations of the larynx and trachea.**—The larynx and trachea are liable to inflammations of very varying forms and degrees of intensity.

1. **Diphtheria.**—This disease depends on the action of a specific microbe, the bacillus of diphtheria.

Bacillus of Diphtheria, Klebs-Loeffler bacillus.—This bacillus is of great importance in view of the fulness of our knowledge regarding it, of its practical consequence as the causative agent in a widely spread disease, and of the recently devised methods of treatment by blood serum.

The bacillus varies somewhat in size. It is usually about the same length as the tubercle bacillus, but broader. The most common form is that of a straight or slightly curved rod a little thicker at one end than the other. In some forms there is clubbing of the ends of the rods; in others the ends are tapered off. (Fig. 505.) The bacillus is stained by watery solutions of the ordinary aniline dyes, but especially by Loeffler's methylene-blue. The irregular disposition of the protoplasm in stained preparations is a striking and constant feature, conferring a beaded or streaked appearance which is very characteristic. The bacillus is not motile. It grows readily on ordinary culture media, but especially on blood serum, or glycerin agar. It also grows in milk and in sterilized urine. A temperature between 20° and 42° C. is required.

The organism is found in the exudation in all cases of true diphtheria, and it can be so readily cultivated and recognized that its presence is used for diagnostic purposes. It may linger even for months about the parts after the attack is over, thus constituting a prolonged danger of infection. It is associated in some cases with the **Streptococcus** and **Staphylococcus pyogenes** so as to produce a **Mixed infection**. Such cases are peculiarly frequent in young children and are very severe, the disease tending to spread downwards to the lungs (Roux and Yersin). In scarlet fever the throat condition, which resembles that in diphtheria, is due to the streptococcus alone. The bacillus is pathogenic in many animals, especially guinea-pigs, sheep, goats, dogs, and many others. Horses are somewhat tolerant of the cultures. Inoculation in the trachea, vagina, etc., of guinea-pigs produces local phenomena similar to those observed in man. There are also the general toxic symptoms, and in prolonged cases the paralyses such as are met with in patients.

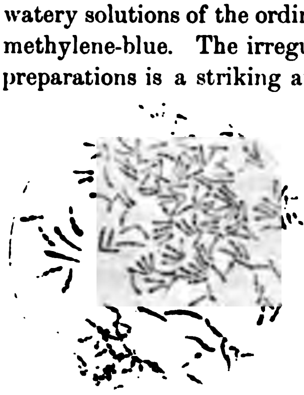

Fig. 505.—Bacilli of diphtheria. Various forms are shown. × about 1000.

The bacillus frequently extends to the lungs, especially in case where the larynx and trachea are involved. In the lungs it produce an acute inflammation or broncho-pneumonia. On the other han it may be associated in the lungs with pyogenic cocci in a mixe infection, or the latter may alone be the cause of the pneumoni The bacillus is englobed by the epithelial cells of the alveo and not by the leucocytes, although the latter form the chief co stituents of the exudate. The bacilli have been found in t spleen, bone marrow, and blood as well as in the lungs, the la mentioned being their place of entrance.

Immunity is producible in animals by the graduated administrati of increasing doses of the cultures or of the toxin free from the microb ultures themselves may be used in the horse, which is less tible than some other animals. The blood serum of immunized ls is effective in protecting susceptible animals by means of the xin which it contains. The serum is tested on susceptible ls, as the guinea-pig and rabbit, so as to determine the degree of iciency.

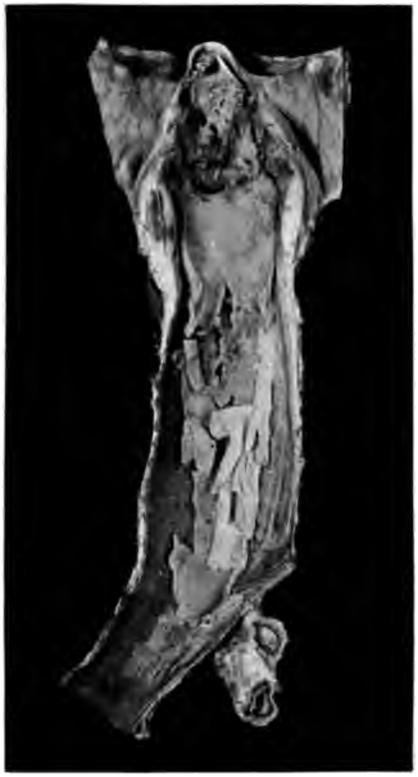

Fig. 506.—Diphtheria of larynx and trachea with extension to the bronchi.

mouth and pharynx of healthy persons not infrequently contain llus which resembles that of diphtheria but is not virulent. This one of the many forms of the Pseudo-diphtheria bacillus.

we have seen above, the local action of the microbe is not limited larynx and trachea, but usually affects also the fauces and ntly the naso-pharynx. It very often extends downwards into onchi (Fig. 506). Besides its local action the **toxin** absorbed into ood produces the serious effects already referred to, especially on ripheral nerves (see p. 693).

The local action consists in a violent inflammation of the mucous membrane, the results of which differ somewhat in the fauces on the one hand and the air passages on the other. The conditions in the former situation are described further on under the diseases of the

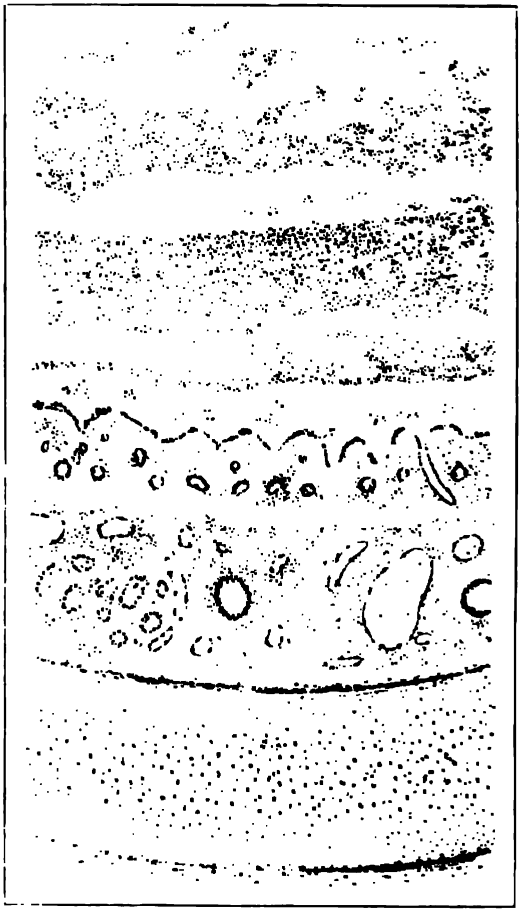

Fig. 507. The larynx in diphtheria. × 50.

Alimentary canal. In the larynx and trachea as in the fauces a catar is the first sign of inflammation. The mucous membrane is hyperæm and there is increased mucous secretion. This is succeeded by the fo mation of a **fibrinous exudation** which covers the mucous membra with a whitish **false membrane** (Fig. 507). The false membrane co sists of fibrine and leucocytes. The mucous membrane at the sam ime shows evidence microscopically, of the most intense inflammation. he vessels are dilated and the tissue is permeated with leucocytes in nmense numbers. As already mentioned, the bacillus is found in the lse membrane, usually in association with other microbes. It is eadily separated by cultivation.

Croup is a name generally given to membranous sore throats in which the xudation is mainly or entirely in the larynx and trachea. The name was first pplied before the eminently contagious diphtheria was distinguished, and it was ommonly understood to designate a peculiarly violent inflammation of the air ssages. There seems to be no doubt that, nowadays at least, the great majority cases of croup are really cases of diphtheria in which the disease is mainly or tirely in the larynx and trachea. The name is also given to throat affections in neral, in which respiration is accompanied by a crowing sound, this being indeed e original meaning of the term Croup, which is a Scottish word signifying the und made in such cases.

We have seen that in the larynx diphtheria produces an inflammation in which, fter the shedding of the epithelium, a fibrinous exudation occurs. It is asserted by me that the diphtheritic poison is the only agent capable of producing this form f inflammation. Looking at the matter from a purely pathological point of view part from clinical experience, it certainly seems possible that other irritants may roduce similar results. Croup has been produced artificially in rabbits by the njection of ammonia into the trachea (Weigert), and in cases of poisoning by aseous ammonia a definite membrane has been found lining the trachea and ronchi (Monro and Workman). In these cases the irritant first kills the epithelium, nd then fibrine is deposited. If croup occurs in man apart from diphtheria, the ritant must be strong enough to destroy the surface epithelium. Apart from the tion of microbes, such an irritant must be of rare occurrence. We shall see afterards that in rare cases we meet with a bronchial croup where there can be no estion of diphtheria, and so we may have laryngeal and tracheal croup of a mple inflammatory kind. In such cases there will be no signs of general disease, t all the symptoms will be referable to the local inflammation and obstruction of e larynx. It should be added that laryngeal croup has been met with in small-ox, measles, pyæmia, etc., and in that case it is to be ascribed to the action of pecific morbid poisons as in diphtheria.

2. **Acute catarrh of the larynx and trachea.**—We have seen that **cute catarrh** forms the first stage in diphtheria; it is the result of e action of the specific poison. Similarly we have acute catarrh measles and small-pox, with a specific eruption similar to that the skin along with the acute catarrh, which may, in exceptional ses, go on to the formation of a fibrinous exudation as in diphtheria. typhoid fever we may also have acute catarrh, which, according to ppinger is of similar significance to the affection of the intestine, ing due to the specific agent. Catarrh occurs also as an independent fection, just as nasal catarrh does, and in this case, although usually ight, it may assume a very severe character. Lastly, a catarrh may e set up by the inhalation of irritating chemical fumes.

There is, as in other inflammations, hyperæmia and exudation. The mucous membrane is red as seen during life, but on post-mortem examination the redness has usually disappeared entirely, the vessels being emptied by the shrinking of the tissue. The exudation is originally mucous in character, and is not generally very abundant. After a time, as in the case of nasal catarrh, it usually assumes a more purulent character. The swelling of the mucous membrane is not usually great, and there is not commonly any serious obstruction. On the other hand, in children a slight catarrh may bring on a sudden suffocative attack due to spasm of the muscles of the glottis (*vide ante*). As an unusual complication of acute laryngitis may be mentioned œdema glottidis, the condition next to be described.

Œdema glottidis.—This name is applied to a comparatively sudden œdematous swelling, causing often a serious or even fatal obstruction of the larynx. The œdema is in most cases an inflammatory exudation, but it occurs in Bright's disease as part of a general œdema. It may be part of a simple inflammation of the larynx, or may be connected with diphtheria, or the pustular inflammation of small-pox, or syphilis, or tuberculosis; or the inflammation may be propagated from the pharynx and fauces, or from the inflamed perichondrium. The condition is not an œdema of the mucous membrane itself; that would produce a very moderate swelling; but it is an inflammation and œdema extending to the submucous tissue. In most parts of the larynx there is little or no submucous tissue, the mucous membrane being bound down to the perichondrium. There are some parts, however, where the tissue is looser, chiefly the base of the epiglottis, and to a less extent, the whole epiglottis, the ventricular bands, and, most of all, the ary-epiglottic folds. The epiglottis is swollen, especially at its base; the ary-epiglottic folds are usually much tumefied, appearing as rounded tumours projecting backwards from the base of the epiglottis. These rounded swellings form indeed the most prominent appearances. The ligaments passing from the epiglottis to the tongue are also sometimes swollen. Examined from above the tumefied ary-epiglottic folds conceal the parts beneath, but on laying open the larynx after death it is found that the ventricular bands (false cords) are tumefied, although the true cords are usually very little affected. The œdema may affect the submucous tissue in the trachea for some distance below the glottis. If the swollen parts be cut into, a fluid exudes which is usually sero-purulent and sometimes almost purulent.

3. **Chronic catarrh.**—This is a common result of repeated attacks of acute catarrh, but may occur spontaneously. It is chiefly characterized, like other chronic inflammations, by new-formation of tissue; the mucous

embrane is thickened, and its surface is irregular. The increase is ainly of connective tissue which, having the usual characters of that sulting from inflammation, gives rigidity to the parts. The movable ructures of the larynx are thus rendered more or less stiff, and hoarse-ss is the result. Not infrequently flat superficial ulcers or erosions rm, and these have their seats most commonly at the posterior comissure. The racemose glands of the larynx may undergo special largement so as to appear as rounded prominences. They sometimes lcerate, and so give rise to small crater-shaped ulcers, which are chiefly be seen on the epiglottis and ary-epiglottic ligaments. The thickning and contraction of the connective tissue are sometimes so great s to produce very great **Stenosis of the larynx**, so that tracheotomy is eeded to permit of respiration. Sometimes mucous polypi form on the surface, and add to the irregularity.

4. **Subglottic inflammation.**—This disease, which is not of very frequent occurrence, is an inflammation of the mucous membrane beneath the glottis. It may be acute at its onset, but it generally passes into a chronic stage. It has been observed as a sequel to erysipelas and typhus fever, and may take origin apparently in inflammation of the perichondrium. In acute cases there may be considerable œdematous swelling. In the chronic form there is thickening of the mucous membrane as in ordinary chronic laryngitis. The inflammation is often just beneath the cords, and so may produce fixation of them, but it may occur further down, and is not infrequently in patches interrupted by normal mucous membrane.

5. **Inflammation of the perichondrium. Perichondritis.**—This disease is rarely a primary one, being induced chiefly by syphilitic and tubercular inflammations, especially when there is deep ulceration extending down to the perichondrium. It occurs occasionally as a sequel of typhoid and also probably of typhus fever. It has usually a somewhat chronic course, but may be acute, and in either case it ends in the formation of pus under the perichondrium. The pus, accumulating under the perichondrium, cuts off the cartilage from its source of nutrition, and, just as in periostitis, this is usually followed by necrosis of the cartilage. The destruction of the cartilage may be a slow process, and there may be a kind of caries followed by necrosis. This disease is generally confined to one cartilage at the outset, the cricoid being most frequently attacked, but it may extend to others. When suppuration has occurred the inflammation spreads to structures around, and we may have burrowing of the pus under the mucous membrane for some distance, or even outside the larynx among the structures of the neck.

The necrosed cartilage is, by degrees, separated from the living. It is usually discharged into the larynx, but the pus sometimes forms an external opening through which the cartilage may pass. There is usually great deformity of the larynx, which may be partly due to the primary disease and partly to the collapse resulting from loss of the cartilage. When the cartilage is discharged it is generally found calcified or ossified, and it is a question how far the calcification precedes the inflammation. Dietrich has suggested that, in the case of the cricoid cartilage, ossification may sometimes be the primary condition, and that the inflammation may be induced by the pressure of the hardened cartilage against the vertebral column.

IV. **Syphilis and Tuberculosis of larynx and trachea.**—1. **Syphilis.**—In the secondary period of syphilis the larynx is frequently the seat of catarrhs which are to be classified along with the various inflammations of that stage. There may be in this period slight erosions of the surface, but no proper ulceration.

In tertiary syphilis the larynx is occasionally attacked, and we have here, as in other situations, irregular infiltrations of granulation tissue, gummatous new-formations, ulcerations, etc. (See Fig. 508.)

The lesions may be at first comparatively superficial, consisting of thickenings and elevations of the mucous membrane so as to form irregular papillary projections (*Condylomata*), which sometimes imitate in appearance epithelioma of the larynx.

Much more characteristic, however, are deep infiltrations and ulcerations. The mucous membrane and submucous tissue are infiltrated and thickened, ulcers develop, first as a general rule in the epiglottis, but they are prone to extend deeply and widely so as to destroy large portions of the epiglottis or the whole of it. We have already seen that the ulceration may lead to perichondritis and necrosis of the cartilage with still wider results. With all this there is great new-formation of connective tissue with corresponding deformity, and, if the ulcers heal, the contraction of the cicatricial tissue leads to great deformity and not infrequently to such obstruction of the glottis as to require tracheotomy.

Congenital syphilis sometimes manifests itself in the larynx. It may be in the form of a superficial catarrh, sometimes accompanied by œdema glottidis, or there may be a superficial infiltration of the mucous membrane. It is rare to have a deep infiltration and ulceration such as is common in ordinary syphilis.

2. **Tuberculosis. Laryngeal and Tracheal phthisis.**—Tuberculosis of the larynx is usually secondary to pulmonary phthisis, the mucous membrane being infected by the sputum from the lungs; it occurs in

about 30 per cent. of the cases of tuberculosis of the lung. It is occasionally primary. Even when the laryngeal tuberculosis is secondary to that of the lung, it may seriously aggravate the latter by the infective material from the ulcerated surfaces being carried into the lung by insufflation.

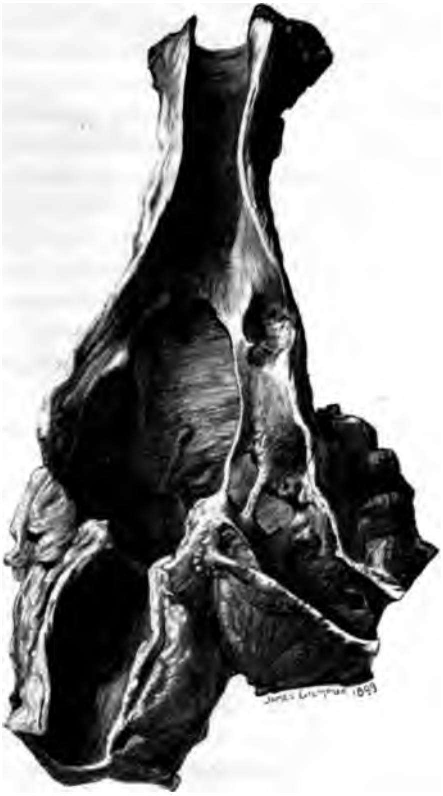

Fig. 508.—Syphilis of trachea and bronchi.

The author has recorded a case of primary tuberculosis of the larynx. On the other hand, from observation in several cases he is induced to believe that, not infrequently, a slight pulmonary tuberculosis produces an infection of the larynx, and that the latter may advance while the former retrogrades. The laryngeal phthisis may thus slowly go on to ulceration while the pulmonary affection heals. Subsequently the lung may become re-infected from the larynx. This is the explanation of the fact that in cases of ulcerated laryngeal tuberculosis, there is often a very rapid and extensive tuberculosis of the lung, which presents the features of an almost simultaneous infection.

In cases of phthisis pulmonalis the mucous membrane of the larynx is frequently pale from anæmia, but this may be nothing more than a manifestation of a general anæmia secondary to the wasting disease of the lungs. The first result of the actual tubercular disease is inflammatory thickening of the mucous membrane. There is at first chiefly an exudation of serous fluid and cellular infiltration so that it is mainly an œdematous thickening. It is most marked in the epiglottis and ary-epiglottic folds, these latter often showing themselves as rounded prominences (see Fig. 509). In this stage microscopic examination shows the presence of tubercles with their characteristic structure, along with the cellular condition of the inflamed tissue. The tubercles are in the mucous membrane and the submucous tissue, the epithelium being as yet intact.

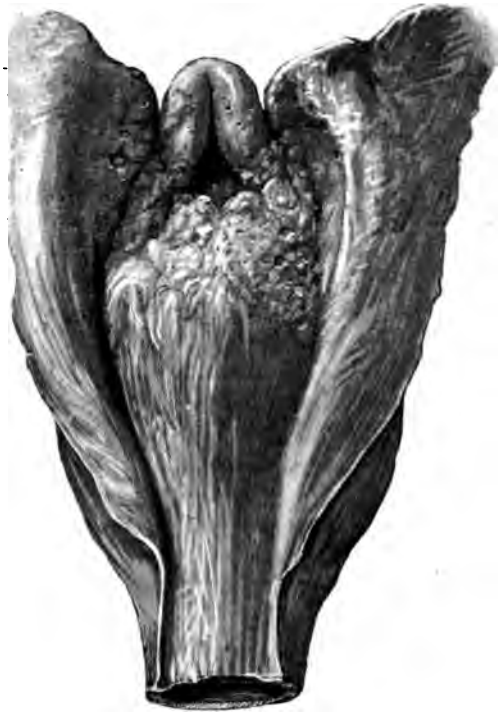

Fig. 509.—Tuberculosis of the epiglottis and ary-epiglottic folds. The pharynx is also involved.

To the thickening succeeds ulceration, the ulcers being at first small and superficial. These ulcers result from the caseation and softening of superficial tubercles. By coalescence larger ulcers form out of the smaller ones, and there is a continual tendency to spreading. As a rule there are many ulcers, and between them is thickened mucous iembrane, which at the borders of the ulcers sometimes presents regular projections like **papillary outgrowths**. The ulcers are at rst superficial, but as the disease progresses considerable destruction f tissue may result. The vocal cords are not infrequently destroyed, nd so there is loss of voice, but the voice may be lost from the rigidity f the structures caused by thickening from chronic inflammation. gain, perichondritis not infrequently follows, with suppuration, and his causes still further inflammatory manifestations.

Ulceration not uncommonly exists in the trachea and bronchi as well s in the larynx. There are many ulcers, and it is not uncommon to ind the cartilaginous rings of the trachea extensively exposed. With hese ulcerations of the trachea there is swelling of the mucous memrane around and sometimes a perichondritis with necrosis.

The lymphatic glands in the neck are affected secondarily to the rynx; they are the seat of tuberculosis as already described, and heir enlargement may, in some cases, aid in the exact diagnosis of he disease in the larynx.

Leprosy produces in the larynx thickenings and ulcerations similar o those of the skin (see Fig. 77, p. 207).

Glanders also attacks the larynx, producing the lesions already lescribed.

Rhinoscleroma not infrequently affects the larynx (see p. 817).

V. **Tumours of larynx and trachea.**—The most frequent form of umour of the larynx is the **Papilloma**. This tumour is often preceded y catarrhal conditions, and is particularly common in persons who, om the nature of their profession, use the voice frequently. But often occurs without either of these predisposing conditions. The umours most frequently grow from the vocal cords, where the pithelium is flat. They consist, like other papillomas, of a basis of onnective tissue forming numerous conical projections covered with pithelium (see Fig. 510). The epithelium may be thick, and the onnective tissue dense, so that the tumour is like a hard wart; or the pithelium may be thin and the connective tissue soft, so that the rowth is soft like a soft wart or condyloma. The growth may occupy small surface of the cord, being partially pedunculated, but it often as a considerable base, forming a shaggy, irregular outgrowth.

A kind of false papilloma occurs, as we have already seen, in some ases of tubercular or syphilitic ulceration of the larynx. Sometimes, lso, the surface of an epithelioma has a papillary character.

Next to the papillomas the **Fibromas** are the commonest tumours n the larynx. Morell Mackenzie found in one hundred cases of nonalignant tumours, sixty-seven papillomas and sixteen fibromas. They are tumours of slow growth, mostly seated on the cords or at the base of the epiglottis. They consist of firm or soft connective tissue, those of firm consistence being the commoner. They are usually more or less pedunculated, and their surface is generally smooth, although it may be irregular or even furnished with papillæ. They are usually small tumours from the size of a split pea to that of an acorn.

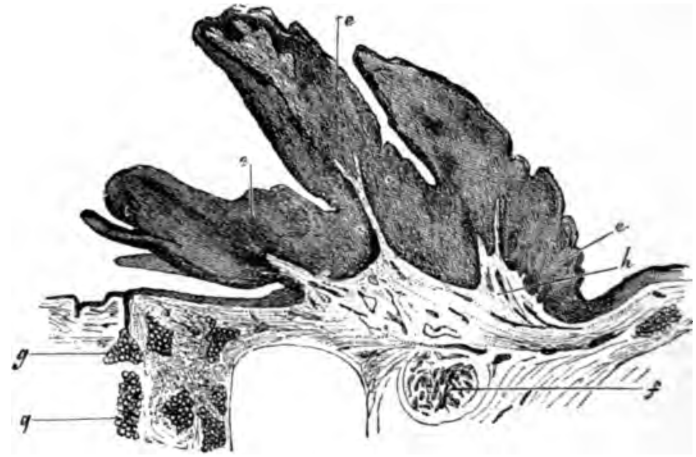

Fig. 510.—Papilloma of larynx. *e, e*, greatly thickened epithelium; *h*, connective tissue; *g*, mucous glands; *f*, a gland at base of tumour atrophied by its pressure. × 20. (CORNIL and RANVIER.)

Mucous polypi occasionally occur, but are much less frequent than in the nares. They very commonly undergo transformation into cysts, and their most frequent seats are the epiglottis and the ventricles of Morgagni.

Other forms of simple tumours are uncommon, but cases of **Lipoma**, **Myxoma**, and **Angioma** have been recorded. **Cartilaginous tumours** formed by outgrowth from the normal cartilages have been found. They are usually multiple and sessile. They may project considerably into the larynx, and, being covered with mucous membrane, may be mistaken for one of the commoner tumours mentioned above.

Sarcomas of the larynx are of occasional occurrence. They are usually of the spindle-celled form, but may be round-celled. They may grow to a considerable size, and are, of course, prone to recur unless the whole larynx be removed along with the tumour.

Cancer of the larynx occurs chiefly in the form of flat-celled **Epithelioma**, growing usually from the ventricular bands, but also originating in other parts. There is first a limited infiltration which extends in area, and gradually advances, involving the parts indisninately. Very commonly there is an abundant papillary growth the surface so that there is a resemblance to the cauliflower cancer o the papilloma. The central parts of the growth undergo ulcera- while the disease is extending at the periphery. In this way at destruction of tissue may result, and the parts present great ormity. An epithelioma may also extend from a neighbouring t, particularly from the tongue.

Tumours are of very rare occurrence in the trachea.

Foreign bodies and parasites are very uncommon in the larynx; y give rise to violent expulsive efforts by coughing. Various icles may pass into the larynx, especially in children, such as tons, peas, pieces of food, etc. Round worms have been known to lge there. If a foreign body lodges in one of the pouches of the ynx it will excite inflammation.

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C.—THE BRONCHIAL TUBES.

Introduction.—In order to appreciate the changes which occur in fections of the bronchi, it is necessary to refer to some points in the ructure of the tubes. The mucous membrane is covered with epitheum the superficial layer of which is cylindrical and ciliated. Beneath e epithelium there is a basement membrane consisting of a translucent homogeneous substance which has few nuclei and is believed by some to be traversed by infrequent channels or canaliculi. Beneath the basement membrane there is the mucosa, consisting of a highly vascular connective tissue, with bands of elastic fibres. In the superficial parts of the mucosa are also found little masses of lymphoid tissue not having the defined form of the closed follicles of the intestine, but similar in structure though much smaller. In the deeper parts of the mucosa there is a layer of smooth muscle, the muscularis mucosæ, consisting chiefly of circular fibres, but with some longitudinal ones. Outside this we have the sub-mucosa or adventitia, containing the mucous glands whose ducts penetrate the mucosa and open on the surface by trumpet-shaped orifices. The submucosa is continuous with, and really forms a part of, the general interstitial connective tissue of the lung. In this loose adventitia the cartilages are embedded, and there are abundant serous and lymphatic spaces which are in communication with those throughout the lung, the perivascular lymphatics and others.

The diseases of the bronchi stand in close relation on the one hand to those of the larynx and trachea, and on the other to those of the lungs, and it is impossible to draw an absolute line of distinction on either side. The affections of the larger and middle bronchi are essentially like those of the larynx and trachea, and this is consistent with the fact that in structure these parts are similar. As we pass down the bronchial tree, however, the structure changes considerably. The cartilaginous plates become irregular and smaller, and finally disappear; the elastic tissue becomes more completely incorporated with the mucous membrane, so as to form a single layer which becomes thinner as the tube diminishes in calibre: the bronchial glands altogether disappear in the finer tubes. The bronchial tube thus becomes more simple in structure, and approximates to that of the lung alveoli. So it happens that in their diseases the finer bronchi are more allied to the lung parenchyma, and are often involved with it. We shall afterwards see that in acute catarrhal inflammation of the lungs the disease often begins in a capillary bronchitis, and is sometimes described under that name.

I. **Inflammation of the Bronchi. Bronchitis.**—Various forms are distinguishable. This is an inflammation of the larger and middle-sized tubes, but not involving to any considerable degree the finer ones. In the slighter forms of bronchitis the larger bronchi and the trachea are mainly affected. In fact, it frequently happens that along with a slight laryngitis there is a tracheitis and a bronchitis of the larger stems. In the more definite cases of bronchial catarrh it is the e-sized tubes that are chiefly involved. As already noted, capil- ronchitis associates itself with inflammation of the parenchyma lung, and will be considered in that section.

Bronchial Catarrh. Ordinary Bronchitis. Causation.—The hial mucous membrane exposed to the inspired air presents g degrees of sensitiveness to variations in temperature and wise. Much that has been said under nasal catarrh is again able here. It is to be added, however, that in many persons is a special proclivity to recurrent attacks of bronchitis. This e due to an inherited weakness, but is perhaps more frequently oned by an acute bronchitis which has left the bronchi consider- ltered in structure, has rendered them, in fact, the least resistant f the body. In such persons bronchitis may be set up by cold, order of the stomach, or by some other trivial cause. Valvular e of the heart frequently predisposes to bronchitis by causing a nent passive hyperæmia of the mucous membrane.

nchitis mostly occurs as recurrent attacks of acute inflammation, between the attacks the inflammation has a more chronic char- Hence in many instances the lesions of acute and chronic mation are more or less conjoined.

Acute Bronchitis.—The first phenomenon here is active con- n of the highly vascular mucosa with swelling both from tion of the vessels and from exudation. The epithelium under- lesquamation, but there is at the same time proliferation in the r layers. There is, in addition, exudation of leucocytes from essels of the mucosa, and the latter is infiltrated with round cells ig. 511). The mucous glands are much affected. Their interstitial is infiltrated with round cells, so that the gland tissue is somewhat red in sections, and at the same time the glandular epithelium proliferation and mucus is abundantly secreted. It will be ved that the exudation, so far as the mucosa is concerned, must beneath the basement membrane, and no doubt this structure hat interferes with the passage of fluid and leucocytes to the e. But Hamilton is probably in error in regarding it as forming lmost complete barrier. There are channels, as noted above, gh the basement membrane. By these and by the mucous glands xudation reaches the surface of the tube.

e **Exudation** in bronchitis is important as it forms **the Sputum**, gives its characters to the latter. In the normal condition the us glands secrete enough mucus to keep the membrane moist, the ion consisting of a glairy fluid containing a few leucocytes which ere called mucous corpuscles. The fluid owes its glairy or sticky character to the fact that it contains mucin, a substance allied to albumen and secreted by the mucous glands. This normal secretion catches and holds the minute particles forming the dust which we inhale with the air, and the vibratile cilia of the epithelium, acting towards the outlets, carry mucus and dust outwards, to be swallowed or expectorated. In bronchitis the secretion, variously altered, is mixed with the exudation from the vessels. At first there is slight increase of the secretion, and it is chiefly concentrated and tough. As the disease progresses it becomes more abundant but less tough and less transparent, and this is brought about by the increase of the inflammatory exudation consisting of serous fluid and cells. The degree of toughness depends on the proportion of mucin, and the degree of opacity on the quantity of cells.

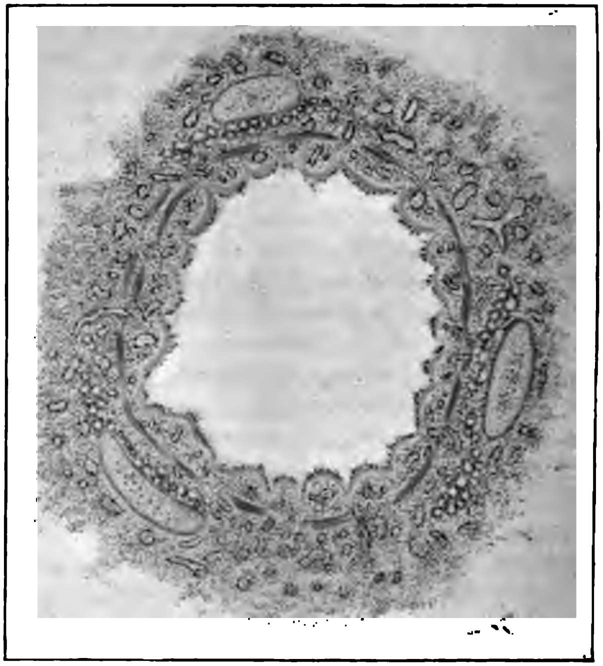

Fig. 511. Section of an inflamed bronchial tube. × 50.

The **Sputum coctum**, or ripe sputum, met with at the acme of the disease, is yellowish white or greenish, and opaque. The sputum as seen in a vessel appears at first sight like pus, but it is much more tenacious. Under the microscope it also resembles pus, the field being crowded with multitudes of leucocytes. But the tenacity of the fluid is n shown by the manner in which the plastic leucocytes are altered hape, being drawn out into oval or more elongated forms according the tough mucus is drawn out. On adding acetic acid the usual elopment of nuclei occurs in the cells, and the intermediate fluid omes markedly opaque from the precipitation of the mucin, which be seen now in fine granules. With acetic acid the sputum assumes the naked eye a whitish, opaque, and almost membranous character.

(*b*) **Chronic Bronchitis.**—We have here, as in other chronic inflam- ations, chiefly a new-formation of connective tissue often accompanied atrophy of the more active structures. In many cases the mucosa sumes more or less permanently a highly cellular character, the in- mmation not subsiding sufficiently to allow of much fibrous develop- ent. The tissue is like a highly vascular granulation tissue and, e it, exudes abundant pus. In other cases an increase of fibrous sue occurs, so that under the basement membrane, instead of a culent vascular mucosa we have strands of fibrous tissue containing stic fibres. This gives a greatly altered appearance to the tube as n in microscopic sections. The mucous membrane is greatly reduced thickness, and the surface shows great irregularity, due to the ying degrees of shrinking. There are even villus-looking projections ible in many cases. The fibrous tissue is largely in longitudinal ds, and these, being hypertrophied, are often visible to the naked as elongated ridges. The mucous membrane so altered is atrophied d indurated, and the atrophy sometimes extends to other structures. e muscularis mucosæ is somewhat persistent and may even undergo pertrophy. The mucous glands and even the cartilages undergo rophy.

In chronic bronchitis the **sputum** is often very abundant, and may sero-mucous with comparatively few leucocytes, but is liable to be termittently semi-purulent. The sputum is not so tough as in more ute cases, and is often very frothy. In some very chronic cases there an abundant cellular exudation—the sputum is almost like pus and s not the toughness of the sputum coctum. Large quantities of pus ay thus be expectorated. In these cases it may be supposed that ucocytes are present in the walls and outside the bronchi as well as the expectoration, and it is in such cases that we may look especially r dilatation of the tubes.

2. **Septic Bronchitis. Fœtid Bronchitis.**—Where highly irritating ecomposing fluids are present in the bronchi, they produce acute flammation of a suppurative character. This occurs chiefly under ree conditions. In the first place local obstruction of bronchi causes e secretion to stagnate and accumulate, and putrid decomposition is

liable to occur. This is the mildest form. In the second place foreign bodies lodging in the bronchi give rise to abundant secretion of fluid which decomposes. This is more fully considered at p. 841. Lastly, gangrene of the lung leads to it, by producing putrid juices which pass into the bronchi. In the last two cases the whole bronchi of one lung are liable to be affected, and there may even be an overflow into the other lung. There is also liable to be an extension to the parenchyma of the lung, the putrid juices being insufflated.

3. **Fibrinous bronchitis.**—This name, as well as that of **Plastic bronchitis** or **Bronchial croup**, is given to a condition of very rare occurrence and of rather obscure pathology, but yet of great interest. We have seen that in laryngeal and tracheal diphtheria the fibrinous exudation sometimes extends down into the bronchial tubes, and that casts of these are occasionally formed. Taking the other end of the bronchial tree we find that in acute pneumonia the fibrinous exudation which forms in the lung alveoli commonly extends some distance into the finer bronchi, and so we find casts in them. But there are cases in which fibrinous casts form in the bronchial tubes independently, without any disease of the trachea on the one hand or of the lung proper on the other. These cases are somewhat chronic in character, and the expectoration of casts occurs at intervals during months or even years. The casts are of a whitish grey colour and represent the bronchi of, it may be, a single lobe, with their ramifications. These can be seen very beautifully by floating them out in water. Sometimes the fine ends of the casts are swollen out as if they had come from the alveoli. The casts sometimes present on section a stratified arrangement as if the fibrine had been deposited in layers. They show under the microscope fibrine with leucocytes.

The exact pathology and the source of this exudation are somewhat obscure. In some cases where death has occurred shortly after the expectoration of the casts, or where they have been found in situ, there has been little perceptible alteration of the mucous membrane. This has led some to suppose that the fibrine comes from the lung alveoli, and in many cases the lung tissue is considerably altered; there may be phthisis, or pneumonia, or collapse. But it is not apparent to what extent these may be secondary to the bronchitis. A possible indication of the pathology may be afforded by the fact that in a considerable proportion of the cases there has been hæmorrhage from the lungs.

II. Stenosis and Dilatation of bronchi.—1. Narrowing or Obstruction of the bronchi occurs under a considerable variety of different circumstances. It may be the result of inflammation in the bronchial wall itself. There is some swelling of the bronchial mucous membrane in all acute inflammations, and in the case of the finer bronchi, this along with the inflammatory exudation will cause serious obstruction. Hence, in capillary bronchitis (broncho-pneumonia) respiration is ofte seriously interfered with.

In **Asthma** there is an obstruction of the finer bronchi througho the lungs. It is brought on by nervous agencies, but the exact proce in the bronchi themselves is not quite determined. The nervous ori gests spasm of the muscular coat of the bronchi, and the suddenness onset and recovery are consistent with this. There seems little ıbt that muscular spasm is the essential element. On the other ıd, the long duration of the paroxysms in some cases throws doubt the view that spasm alone is the cause. An acute hyperæmia, due vaso-motor paralysis and accompanied by œdema, has been suggested a more probable explanation. From whatever cause there is sudden nosis of the finer bronchi, spasmodic at the outset, but possibly nplicated later on with actual swelling from exudation. Leyden erved, in the sputum of cases of asthma, crystals (sometimes called **yden's crystals**) similar to those found in the blood in leukæmia ıarcot's crystals, see under Leukæmia). He supposes that these stals may set up a reflex spasm of the bronchial muscles, but this w has not been accepted.

Narrowing of the bronchi may be due to **Pressure or Encroachment** m without. **Tumours** not infrequently extend from the root of the g along the connective tissue around the bronchi, and growing there y may compress and narrow a bronchus. In not a few cases the nour infiltrates the bronchial wall, and may even grow through it, as to present itself in the calibre of the tube, thus narrowing it conerably. These conditions occur chiefly in the case of lympho-sarcoma the mediastinum. Tumours by their mere pressure, or aneurysms pinging on a bronchus, may narrow the calibre.

Foreign bodies in the bronchi produce obstruction, and a large one ıgging a main bronchus may lead to serious respiratory trouble. reign bodies in the bronchi, however, may give rise to affections of a fferent kind to be considered in a following page.

2. **Dilatation of bronchi. Bronchiectasis.**—This is a condition of nsiderable frequency, and it arises under a variety of different rcumstances.

(*a*) **Causation.**—In most cases the main agent in causing dilatation f the bronchi is the air-pressure acting excessively and very often ting on bronchi whose tissue is weakened by disease. In regard to e air-pressure we can recognize here as in the case of emphysema ses in which the abnormal pressure occurs during inspiration and others which it occurs during expiration. **Non-expansion or shrinking of lung alveoli** is a cause of bronchiectasis from the action of the forces inspiration. To such cases the term Complementary Bronchiectasis y be applied, the term having a similar significance to complentary emphysema. This is illustrated in certain interesting cases **congenital atelectasis**, in which portions of the lung do not expand birth and remain unexpanded (see Fig. 512). In such cases the inspiratory expansion of the chest is not able to act on the lung alveoli, and so it exercises a dilating force on the bronchi, which may be expanded into a congeries of sacs. (See also under **Hypertrophy** of the lung.) Localized **atelectasis** due to other causes may have a similar result. A more frequent cause is shrinking of the lung by **fibroid contraction.** This occurs in the various forms of chronic inflammation the lungs, and more particularly in fibroid phthisis. The shrinki of the lung tissue is often very great and a complementary bronc ectasis is usually associated with emphysema, the latter occurring the parts of the lung less affected with the fibrous development. cases of this kind the dilatation of the bronchi is partly due to t contraction of the fibrous tissue of the lung. The adventitia of t bronchi is directly continuous with the interstitial tissue of the lur and the shrinking of the latter will act on the bronchial walls, but w do so irregularly according to the relations of the fibrous tissue. Tl is in part the explanation of the irregular expansion of the bron resulting in the saccular form.

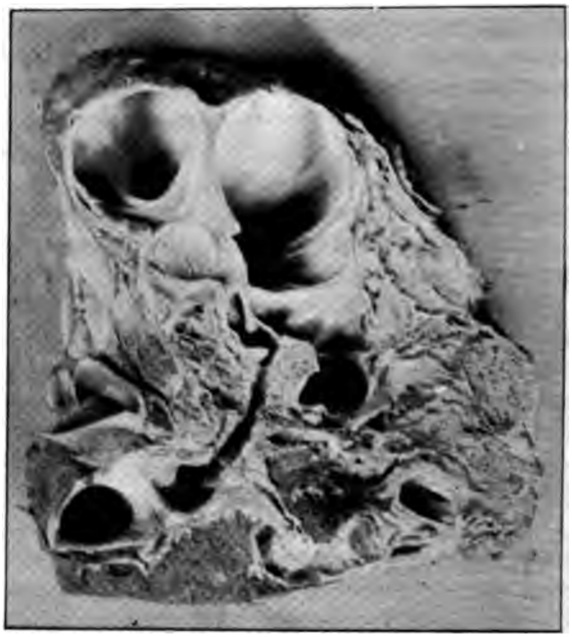

Fig. 512.—Complementary bronchiectasis from old congenital atelectasis. The bronchi in the apical region are expanded into rounded sacs. The collapsed tissue around contained no carbonaceous pigment as if it had never been in use for respiration.

Weakness of the bronchial wall leads to bronchiectasis chiefly from
association with coughing, in which the expiratory forces are in-
ased. In this respect bronchiectasis is comparable with substantive
physema. In chronic bronchitis there is frequently, as we have
n, atrophy of the bronchial wall. This atrophy may be from
rous development, and in that case the wall can scarcely be weak-
ed. But if the wall, as frequently happens, is for prolonged periods
a state of more constant inflammation, so that its tissue is like
anulation tissue, then it is liable to expand. In such cases there
abundant secretion and therefore frequent coughing, and the
rced expirations with closed glottis, acting on the weakened wall,
duce dilatation. The weakening or softening of the wall is even
re manifest in septic bronchitis where there may be extensive
nchiectasis. Grainger Stewart regarded the atrophy as of primary
portance and the probable result of a constitutional, if not hereditary,
ect.

Accumulation of the secretion of the bronchi is also an occasional
se of bronchiectasis. This may act in two ways. The accumulated
retion is apt to decompose and produce septic inflammation, and so
aken the wall. On the other hand, if there be a complete obstruction
a bronchus the accumulation in the parts distal to the obstruction
y dilate the tube. As atelectasis results from such bronchial ob-
uction we have a further cause of bronchiectasis.

(*b*) **Structural changes.**—The various forms of bronchiectasis may
divided into two, namely, the cylindrical and the sacculated.
e **Cylindrical form** occurs mainly where the causal condition has
en more or less of a general one, such as a prolonged bronchitis.
e bronchi, especially the middle-sized ones, are unduly wide, and
eir walls are thinned. The dilatation may be quite regular, but very
ten there are little bulgings or pouches. In the **Sacculated form**
ere has usually been a more local agent at work. The most typical
culated dilatations are found in fibroid phthisis (see Fig. 513), but
y be produced also by any cause which induces shrinking or non-
pansion of the lung tissue (see Fig. 512).

In the sacculated form the dilated tubes assume the characters of
ities, which may be difficult to distinguish from cavities taking
gin in destruction of lung tissue. This difficulty arises in cases of
erculosis, which form the largest proportion of the cases of saccu-
d bronchiectasis. As a general rule the bronchiectatic cavity has a
tinct lining membrane, but this is not always the case, and no cavity
uld be definitely distinguished as bronchiectatic unless a direct
tinuation with an open bronchus is distinguishable.

The microscopic structure of the wall of a bronchiectasis varies considerably according to the causation. Where there is much inflammation, and more particularly in the cylindrical form, the structures of the wall are largely replaced by a highly cellular tissue, in the midst of or beneath which some of the normal structures may remain, such as muscular bundles. In the cases of complementary dilatation there is much greater persistence of the normal tissues, mostly thinned by the stretching and chronic inflammation. The basement membrane is, for the most part, preserved in cases of this sort. The presence of epithelium lining the cavity is not a good criterion for the diagnosis of bronchiectasis, because on the one hand epithelium may grow over the surface of cavities of other origin, and on the other hand the epithelium of a true bronchiectasis may be entirely destroyed and the mucous membrane replaced by granulation tissue.

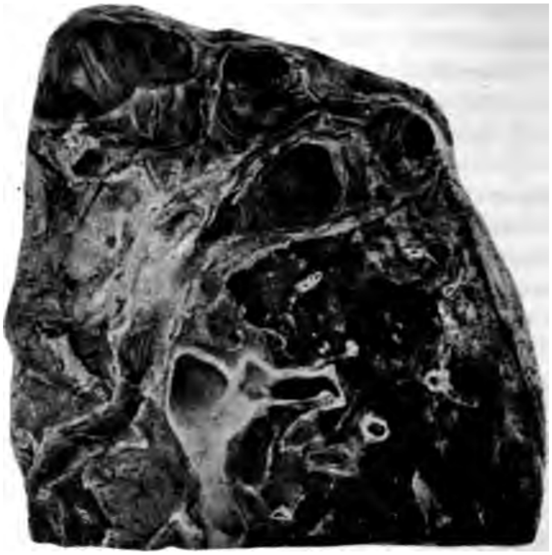
Fig. 513. Bronchiectasis associated with chronic tuberculosis of the lung.

As the secretion stagnates in dilated bronchi whether cylindrical or sacculated there is commonly, during life, at intervals an abundant expectoration, which is often of a highly putrid character.

III. **Tumours of the bronchi and Foreign bodies.**—Simple tumours originating in the bronchi are exceedingly rare. In Fig. 514 is shown a glandular tumour, the structure of which somewhat resembles that of the thyroid gland. **Cancer** not infrequently occurs, originating in the cous glands of the bronchi, although the resulting tumour has rather e characters of cancer of the lung. (See under Cancer of the Lung.) The bronchi are not infrequently involved in tumours growing into e lungs along the connective tissue which accompanies the great ssels and bronchi. This applies more particularly to mediastinal rcomas, which often incorporate the bronchi in their substance and

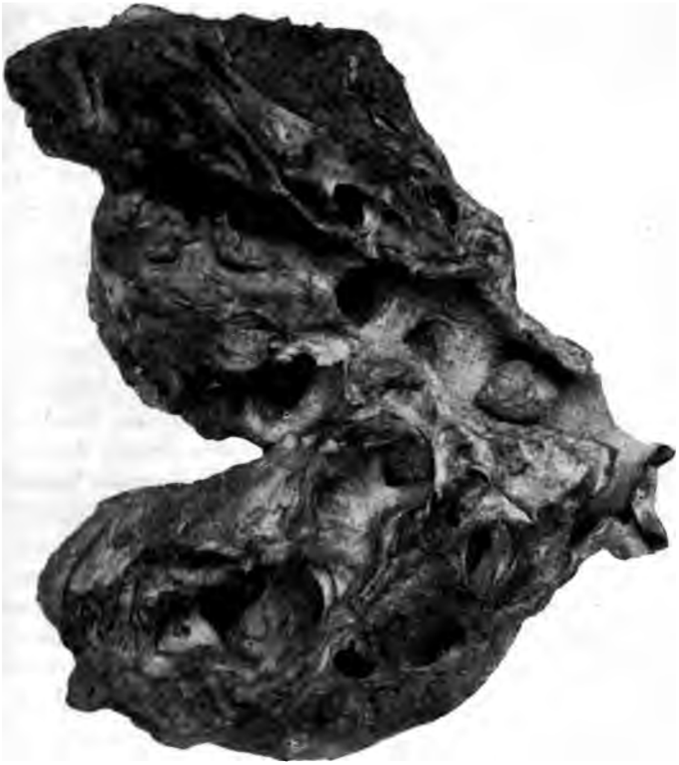

Fig. 514.—Glandular tumour of a bronchus.

se obstruction. Obstruction of bronchi with stagnation of the tents and bronchiectasis are often prominent features in such cases. The bronchi also take part, often very markedly, in tuberculosis of lungs.

Foreign bodies in the bronchi give rise to lesions which often affect s lung as a whole and may lead to appearances and symptoms very e those of phthisis pulmonalis. When a foreign body of some size sses down the trachea and lodges in one of the larger bronchi, it comes a centre of irritation. It irritates the bronchial wall, making for itself a cavity the internal wall of which ulcerates and discharges pus. The discharge stagnates in the cavity and decomposes, and as it is in direct communication with the bronchial tree, it is liable to be insufflated into the finer bronchi and even into the lung alveoli. The whole bronchial mucous membrane is converted into an inflamed and discharging surface, and the discharge is of a highly putrid character. Thus arise some cases of so-called **Fœtid bronchitis**. The inflammation of the bronchial wall renders it less resistant and bronchiectasis often results, the putrid fluid stagnating in the dilated bronchi. There are thus cavities formed which may ulcerate and imitate those of phthisis. In the lung tissue itself there may be developed an acute or a chronic inflammation, the former having the characters of an acute phthisis and the latter more those of a chronic fibroid phthisis. The difference in the result will depend to some extent on the character of the foreign body. If it be a decomposable substance, such as a piece of meat or of bone with meat attached, it is more liable to lead to acute symptoms, while if the body is in itself inert the results may be more chronic.

These remarks are chiefly based on cases observed by the author, who is impressed by the frequency of serious disease of the lungs, resembling phthisis in many cases, brought about by foreign bodies in the bronchial tubes. A fuller account of two such cases is given by the author in his Lectures on Phthisis.

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SECTION V.—CONTINUED.

D.—THE LUNGS.

—**Of the Lungs.** Introduction, as to structure. I. **Malformations.** II. **Atelectasis and Collapse.** III. **Hypertrophy.** IV. **Pulmonary Emphysema,** 1. Interlobular; 2. Vesicular; causation, either substantive or complementary; anatomical changes, involving atrophy; effects of emphysema. V. **Disorders of Circulation.** 1. Active hyperæmia; 2. Passive hyperæmia, chiefly from cardiac lesions and hypostatic; leads to œdema; 3. Embolism; 4. Hæmorrhage: the Infarction, etc. VI. **Inflammations.** General observations. 1. Acute lobar pneumonia; causation; epidemic prevalence. Stages of Engorgement, Red and Grey Hepatization, and Resolution; occasional Purulent infiltration, etc.; Condition of pleura; 2. Acute broncho-pneumonia or capillary bronchitis; 3. Septic Broncho-pneumonia; 4. Diphtheritic pneumonia; 5. Embolic pneumonia; 6. Chronic pneumonia, characterized by induration. VII. **Gangrene.** VIII. **Phthisis pulmonalis.** 1. Definition and historical resumé; 2. Causation; 3. Anatomical changes in (*a*) Caseous form, and (*b*) Fibroid form; 4. Extension of the tuberculosis; 5. Healing process; 6. Hæmorrhage, (*a*) early, and (*b*) late; 7. Condition of pleura—pleurisy and pneumothorax; 8. General effects. IX. **Diseases from inhalation of dust.** X. **General Tuberculosis, Syphilis,** etc. XI. **Tumours** and **Parasites.**

—**Of the Pleura.** 1. Affections of the circulation; 2. Acute pleurisy; 3. Chronic pleurisy; Pleural adhesions; 4. Tuberculosis; 5. Pneumothorax; 6. Tumours.

NTRODUCTION.—In examining the lungs after death we seldom meet with them in a perfectly normal condition. They may be ormally adherent to the wall of the thorax, or unduly pigmented, here may be cicatrices in them, or œdema, and so on. The explana- n of this is that the lungs are peculiarly exposed to deleterious uences in two directions. The air passing into them is apt to carry tating materials with it, and the blood circulating so richly through ir tissue is liable to variations in its constitution and degree of pres- e. We have already seen, for instance, that organic disease of the rt has serious effects on the pulmonary circulation, but apart from t, simple weakness of the heart may, as we shall afterwards see, have important effects on the lung. It must not be forgotten also that there is no organ of the body whose tissue is so intimately related to its blood-vessels as the lungs. These organs are little more than a congeries of blood-vessels with a sufficient supporting stroma. Any deleterious substance circulating in the blood, therefore, is very prone to affect the lungs, especially if there be any special weakness in this direction. We have abundant illustration of this in the frequency of lung complications in the acute fevers.

There are one or two points in the anatomical relations of the lungs which should be kept in mind. They are supplied with two different sets of blood-vessels, those of the **Pulmonary artery** on the one hand, and of the **Bronchial artery** on the other. We should remember the distribution of these, and not confuse effects due to obstruction of the one with those due to obstruction of the other. Then we speak of diseases affecting the **Respiratory surface** on the one hand, and the **Supporting structures** on the other; that is to say, there are some diseases which affect the surfaces of the finer bronchi and of the alveoli, while others involve the walls of the alveoli and of the bronchi and their supporting connective tissue. It is true that these two are generally involved together, but in different cases the one or the other is primarily concerned, and usually retains the lead. It is obvious that to a certain extent the determining cause of the disease will have something to do with this. An agent which acts by being carried into the lungs with the air will mostly affect the surface of the alveoli and bronchi in the first place, whereas an agent arriving by the blood will be more apt to attack the walls. We shall see, however, that to this there are important exceptions, because, on the one hand, the capillary vessels have very close relations with the surface of the alveoli, and, on the other hand, substances arriving from without very readily penetrate into the substance of the lung. A more important consideration arising from the anatomical relations has reference to the distribution of a lesion in larger or smaller districts of the lung. When a disease is one primarily of the parenchyma of the lung, then we should expect it to be distributed over a large extent of lung tissue or over the whole the disease will be **Lobar**. But if the disease is one primarily of the bronchi and affects the alveoli secondarily, then we should expect it extend to the proper lung tissue more irregularly, here and there extension corresponding with a particular minute bronchus; the disease will be **Lobular**.

The **Lymphatics of the lung** are important as they often convey different kinds of solid particles and are the means of dissemination these. The lymphatics are present wherever connective tissue exists y exist in the walls of the alveoli and in the interlobular tissue, in subpleural tissue, and in the connective tissue around the bronchi vessels, where they form the peribronchial and perivascular lym- ics. The internal surface of the alveoli is closely related to the phatics, so that solid particles readily pass from the alveoli into lymphatics and may be carried thence throughout the lymphatic em of the lung, and onwards to the bronchial lymphatic glands. under Inhalation of Foreign Substances.)

I.—MALFORMATIONS OF THE LUNG.

hese are not infrequent, but are mostly of minor importance. rt from absence and exceeding smallness of one or both lungs, ch occur as parts of general malformations, there are cases where le lobes have been wanting, and their place taken by cicatricial ue. These have probably their origin in obliteration of a bronchus arly fœtal life. Again, the lungs may be normal in form, but y small in size. In such cases the whole body, and especially the ulatory system, will remain ill developed.

t is quite common to meet with abnormal lobulation of the lungs, regular lobes being divided by the formation of deep fissures. kitansky has described a case in which an accessory lobe existed ween the base of the left lung and the diaphragm, and quite separate m the lung. It had, however, no bronchus.

II.—ATELECTASIS AND COLLAPSE OF THE LUNG.

These names designate conditions in which the lung alveoli and finer nchi contain no air, but are in a condition similar to that of the al lung before inflation, the internal surfaces of the alveoli being lied to each other. It may be a survival of the fœtal state, or it be subsequently produced by the alveoli being, in some way, tied of their air.

telectasis.—In its strict sense this term is applied to an imperfect ansion of the lung at birth. It is frequently found in new-born dren, being, indeed, a survival of the fœtal state. The lungs have greater or less extent remained uninflated. The non-inflation may due to some obstruction in the bronchi, by meconium or mucus, in most cases it is merely due to the weakness of the inspiratory rts. The new-born child usually cries lustily, and in the deep piratory gasps between the cries the lungs are fully inflated. But he child be weak or has not cried freely, certain parts of the lungs apt to remain devoid of air. The atelectasis of the new-born is most frequent in the lower lobe, and in the posterior parts of this lobe. It may be only in small areas in the midst of the inflated lung tissue, or the greater part of a lobe, or the whole lobe may be affected. In any case the non-inflated part usually shows by its shape that it is the district supplied by one or more bronchi.

The atelectasis shows itself by the smaller volume of the part. If it is in the midst of inflated lung it is depressed below the surface. Like the fœtal lung, it is redder than the normal, firmer to the touch, and non-crepitant when handled. It is important to distinguish this condition from **condensation of the lung,** for which it is liable to be mistaken. In both conditions the lung is devoid of air, but in the case of condensation it is so because the air spaces are filled up with solid material, usually inflammatory exudation.

There is no doubt that a lung which was partly atelectatic immediately after birth may subsequently become perfectly inflated. On the other hand, there is reason to believe that, if the atelectasis persist long the lung becomes incapable of inflation. If the child survive, the applied walls of the lung alveoli adhere and an actual obliteration of the latter occurs. The part gradually atrophies, and it has been supposed that cicatrices sometimes seen in the adult lung and without any obvious cause may have this origin.

Bronchiectasis occurs in consequence of the atelectasis, the bronchi dilating to fill up the space left by the non-inflation, so that the bronchiectasis is complementary (see Fig. 512). In a case observed by the author, and referred to further on under Hypertrophy of the Lung, the greater part of one lung had failed to inflate, and the bronchial tubes were dilated into considerable sacs.

The question arises here whether, after inflation of the lung, portions or the whole may again collapse. We shall see immediately that collapse occurs in the adult, and there is no reason to suppose that it does not occur in the new-born infant. There are undoubted cases of children who have lived over twenty-four hours and have cried, in whose bodies the lungs have been found with only an island here and there of inflated lung.

Collapse of the lung or Apneumatosis.—This is an emptying of the lung of air at any time after its expansion. In some cases it is due to direct **Compression of the lung**; the air is simply squeezed out of it. Usually this arises from the presence of fluid or air in the pleural cavity. In that case the air vesicles may be only partly emptied and may readily recover. But if the exudation is great and remains long, the [illegible] the lung may be pressed upwards and backwards and come to form merely a red fleshy layer flattened against the chest wall. This condition is often called **Carnification**, and in it the tissue appears dark[illegible] pigmented, the absence of blood and the packing together of the lung tissue exaggerating the existing carbonaceous pigmentation. The cause mentioned above is by far the most frequent in producing collapse by pressure, but there are others. Curvature of the spine sometimes causes such a narrowing of a part of the chest that the lung is squeezed or collapsed. Aneurysms or tumours may also compress the lung, but they more frequently cause collapse by obstructing the bronchi. Even distension of the abdomen, by pressing the diaphragm upwards and limiting the chest space, may cause a partial collapse. A great distension of the pericardium may have a similar effect.

A very important cause of collapse is **Obstruction of bronchi.** A limited collapse is exceedingly frequent in bronchitis, especially in children. The collapse very often appears in the form of small wedge-shaped depressions at the edges of the lungs, and may be almost concealed by neighbouring emphysematous lung. But sometimes, especially in children, the collapse may be much more extensive.

One mode in which this collapse occurs has been described by Gairdner. If a pellet of mucus obstructs a bronchus it may act to a certain extent like a ball valve; it is pushed out into the larger tube during expiration, and being drawn back against the bifurcation in inspiration stops the tube. In this way the escape of air during expiration is allowed, but the entrance of air during inspiration prevented. The respiratory movement will thus act, to a certain extent, like an air pump, and the portion of lung tissue concerned will be gradually emptied of air.

Another way in which collapse probably occurs when a bronchus is obstructed has been demonstrated by Lichtheim. It is to be remembered that the lung tissue is elastic, and that left to themselves the alveoli collapse and their walls apply themselves together. If a bronchus be obstructed, and communication with the external air withdrawn, the elasticity of the lung tissue will cause pressure to be exercised on the air contained in the alveoli, and absorption of its gases will be thus promoted. It has been proved that such absorption actually occurs somewhat rapidly, first of the oxygen, then of the carbonic acid, the nitrogen being slowest of absorption. The lung of course collapses as the air is absorbed.

It has just been stated that collapse from bronchial obstruction is most common in the bronchitis of children, but it is necessary to observe that in children, in whom the form called capillary bronchitis is common, this disease is often accompanied by a condition which is apt to be mistaken for collapse, namely, lobular condensation. The inflammatory process in the bronchi readily passes in children to the lung alveoli, and the products fill these up, causing condensation of a portion of the tissue which has a wedge-shaped configuration similar to that of the collapsed portion. Of course, these two conditions may co-exist in the same lung, or we may even have a combination of them, the collapsed lung becoming the seat of inflammation, and so passing into the condition of condensation.

Literature.—Heller, D. Arch. f. klin. Med., xxxvi.; Coats, Trans. of Clin. Soc. of Lond., 1884; Gairdner, On bronchitis, 1850; Lichtheim, Arch. f. exper. Path., 1879.

III.—HYPERTROPHY OF THE LUNG.

This occurs as a **Compensatory** process perhaps more frequently than is usually supposed. There is evidence to show that in persons who go to reside in high altitudes, the chest increases in size, the greater requirements of the attenuated air apparently inducing increased respiratory movement and by degrees a permanent enlargement of the lung. It is also probable that in cases of phthisis which recover with loss of a certain portion of lung substance, the loss may be partly made good by a true hypertrophy of the lung, although there is also observed in such cases an emphysema by which the space is filled up without a proper hypertrophy. Hypertrophy in cases of phthisis will be promoted by residence at a high altitude.

An unequivocal compensatory hypertrophy of the lung occurs **in consequence of atelectasis.** There may be in this case a great enlargement of the expanded lung so as partly to fill the place of the non-expanded part. In such cases there is not probably any numerical increase of lung alveoli, but these are enlarged, their walls expanded, and the capillaries elongated or multiplied.

A case occurred to the author which distinctly manifested the characters mentioned above. The left lung was of very small dimensions, especially the upper lobe, which appeared merely as a membranous structure in which dilated bronchi could be felt. There was no pigment in this lobe, and not a trace of lung parenchyma. The lower lobe contained the ordinary carbonaceous pigment in limited amount, and was greatly reduced in size.

The right lung was of very unusual volume, extending across the middle line, so that its edge reached beyond the left nipple. The enlargement seemed to be due to an addition of lung tissue which threw forward the anterior parts. The supra-clavicular part of the lung was normal, and its anterior border indicated the position of the normal anterior margin. Below and beyond this, however, the lung extended into the other half of the chest. This part of the lung had not the appearances of emphysema, but was bulky and consisted of sound pulmonary tissue. The right ventricle of the heart was greatly enlarged, and the pulmonary artery showed a remarkable thickening of its wall, there being scarcely any difference between it and the aorta.

The absence of pulmonary tissue in the upper lobe of the left lung indicated that the collapse had been of long standing, and the entire absence of pigment showed that if not congenital it had occurred in very early life. The enlargement of the right lung was thus compensatory, dating from a period when the organ was in a state of growth. The compensation seems to have been somewhat effective, as the person lived to the age of 46, and it was only during the later months of his life that he suffered from serious dyspnœa, followed by signs of venous engorgement. The remarkable thickening of the pulmonary artery without any appearance of atheroma, also seems to point to a compensatory hypertrophy of the right ventricle during the period of growth, the vessel in its growth accommodating itself to the increased blood-pressure. It may be added that the left pulmonary artery had only about a third of the calibre of the right, but the main bronchus was of equal size on the two sides. A somewhat similar case is described by Recklinghausen.

Literature.—Coats, Lect. to pract., 1888; Schuchardt und Recklinghausen, Virch. Arch., ci., 1885, p. 71.

IV.—PULMONARY EMPHYSEMA.

This name includes two distinct lesions, in one of which air escapes into the connective tissue of the lung and distends the connective-tissue spaces, while in the other the alveoli are over-distended and various other changes result, but the air does not escape from its natural chambers. It will be seen that the first form is comparable with surgical or cutaneous emphysema, while the second is essentially different.

1. **Interlobular or Interstitial emphysema.**—This form, which is rare, occurs when the air vesicles or bronchi are ruptured and the air escapes into the interstitial tissue. The air vesicles may be actually torn open by a broken rib coming against the lung, or by the lung being directly wounded. On the other hand, the air vesicles may rupture from acute over-distension. Thus it may be the result of very violent expiratory efforts, generally with, but sometimes without, obstruction of the air passages. It has been met with in whooping cough, in diphtheria, and in violent coughing from the inhalation of irritating material (see Fig. 515). The violent efforts with closed glottis cause such compression of the air in the alveoli that at some place the vesicles rupture.

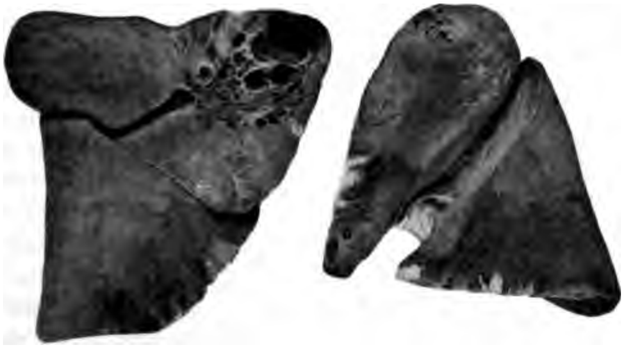

Fig. 515.—Lungs of an infant with interstitial emphysema. The trachea and bronchial tubes contained a large amount of meconium.

As the parts are seen after death the air appears in the form of minute rows of bead-like bubbles, visible through the pleura. These rows of beads demarcate the lobules. Occasionally there are larger bullæ (see Fig. 515), which have been known to rupture externally, and so lead to pneumothorax.

The air sometimes travels along the connective tissue for some distance, just as in the case of **Subcutaneous** or **Surgical emphysema**. It may pass to the root of the lung, and from there up along the trachea and out to the subcutaneous tissue of the neck, and so lead to a surgical emphysema. This has in some cases induced a mistake in diagnosis, as Virchow has pointed out. Interlobular emphysema sometimes occurs in diphtheria, and may lead to subcutaneous emphysema in the way just mentioned. But if tracheotomy has been performed, it may be thought that the emphysema has taken origin in the wound.

An unusual cause of interstitial emphysema was that in a case observed by the author, in which a tuberculous gland burst into a bronchus. The rupture of the bronchus allowed of the passage of air to the parts outside the tube, and the air inflated the connective tissue of the lung on the one hand, and on the other hand extended up to the neck and chest, producing a subcutaneous emphysema.

2. **Vesicular emphysema.**—In this condition the air vesicles are over-distended, and, by partial atrophy of their walls, to some extent coalesced, but without any actual tearing of them.

Causation of emphysema.—There have been differences of opinion as to the exact manner in which the over-distension is brought about. On the one hand, Gairdner asserted that it was produced during inspiration, while Jenner held that it was due to the expiratory force. Probably each of these has its influence, and the cases may be divided according as they are due to repeated and severe expiratory efforts as in coughing (*Substantial emphysema*), or to inspiratory distension, acting especially on one part in consequence of another part being uninflated (*Complementary or Vicarious emphysema*). In the former case we have a more generalized and in the latter a more localized emphysema.

Substantial or Substantive emphysema is due to over-distension during expiration. When the glottis is closed, and Expiration violently performed, the air in the vesicles will be at an increased pressure. The expiratory effort is produced by the muscles causing the movable walls of the chest to be pressed against the lung. The contraction of the abdominal muscles presses the diaphragm upwards, while the ribs are depressed. The lung is thus compressed, but at the same time it is supported by the structures which compress it, and the same force that increases the pressure helps the lung tissue to resist it by increasing the support. When the glottis is closed the whole lung may be regarded as one cavity, and the pressure will be universally diffused. It may be expected, therefore, that if any part of the lung be insufficiently supported the distensile force will tell ecially there. The question therefore arises, Are there any parts ere the lung is not fully supported by the chest walls ? If a p breath be taken, the glottis closed, and the act of expiration orously performed for a few seconds, we find in our own feelings lications that the lungs are over-distended, mainly in the anterior ts and the parts above the clavicles. We can easily understand w this should be. The anterior part of the chest, by reason of flexibility of the costal cartilages, is more movable than the t of it, and the anterior edges of the lungs, as we can see in an mal whose chest is laid open while artificial respiration is carried have very free play. Then, above the clavicle the lung is obviously supported than where the chest has bony walls. We shall see erwards that these, with one or two other parts, are those in ich emphysema, when due to frequent expiratory efforts, occurs st typically.

t will be obvious that, if the lung tissue has lost its elasticity, permanent dilata- of the air vesicles will occur more easily, and will readily extend to parts re fully supported than those mentioned. In Senile Emphysema, to be after-ds referred to, there is a loss of elasticity from the atrophy of old age. But re seems to be in some cases a general loss of elasticity, and it appears as if h a condition were hereditary to some extent. It is true that frequent overtension will cause atrophy of the elastic tissue of itself, but it is quite apparent t in many individuals there is, to begin with, less elastic tissue, or it is less istant, and so we have a predisposition to emphysema, sometimes inherited. A ilar loss of elasticity may be induced by disease, as in a case rcorded by Hertz which a cornet player developed a marked emphysema after an attack of umonia.

Emphysema is liable to occur when frequent and violent expiratory rts are made with closed glottis. Coughing implies such efforts, it is chiefly in diseases where coughing is a prominent feature t we are to look for emphysema from this cause. It is met with -eminently in bronchitis. It also occurs in whooping-cough, asionally in croup, and even in the violent expiratory efforts of turition. As chronic bronchitis is specially a disease of more anced life, we may expect that a preliminary atrophy of the lung ue, implying a loss of elastic tissue, plays an important part in the duction of emphysema in a large number of cases.

Complementary or Vicarious emphysema arises in consequence of er-distension during inspiration. If a part of the lung does not tend fully in inspiration, there must either be a falling-in of the est to a corresponding extent, or else an over-distension of another rt of the lung in order to fill up the space. To what extent one or her or both of these will occur is determined by circumstances, chiefly by the situation of the insufficiently distended part and the time occupied in the occurrence of the lesion.

If a portion of the lung is collapsed, the neighbouring part often undergoes emphysematous distension. It occurs thus in bronchitis, and the wedges of collapse, already referred to, are often fringed with emphysema. We see it also around cicatrices in phthisis, or along with bronchiectasis in fibroid phthisis. Emphysema occurs sometimes to a remarkable extent in connection with general adhesions of the lung, and the emphysema is often very marked at the anterior parts. In this case the adhesions prevent the forward movement and expansion of the lung during inspiration, and there is thus an over-distension in this direction. The opposite lung may project so as to partly fill the space, and its edge may be also emphysematous.

Anatomical changes in emphysema.—We have to do with air spaces of irregular shape and separated by partial partitions, and as the distensile force acts from within, its tendency is to distend equally, and so render the spaces globular. The ultimate bronchial tubes terminate in the elongated passages called from their shape infundibula. From these passages open, by wide apertures, the air vesicles, which therefore cluster around the infundibula and are mere pouches out from them. The distensile force will act first on the infundibulum with its system of air vesicles, causing distension. The tendency will be to render the outline more globular and the cavity simpler. The partitions separating the alveoli atrophy and the infundibulum expands into a simpler cavity (Fig. 516 and *a a* in Fig. 517). Thus while more space is occupied there is less respiratory surface. The infundibulum continues to expand and meets with other infundibula undergoing a similar process. By mutual pressure the adjoining tissue atrophies, and the infundibula communicate by rounded apertures. The larger cavity tends to become simpler by atrophy of all partitions and septa, and so the process goes on by coalescence of neighbouring spaces and atrophy of the partitions. The enlarged air spaces thus produced are of various sizes, up to considerable vesicles or bullæ.

With this atrophy there is great **loss of tissue and of blood-vessels**. Before the actual destruction of the blood-vessels the pressure seems to cause obstruction of them so that they are not able to be injected and appear as white cords. It is stated that this obstruction is effected by the formation of white thrombi. The epithelium for the most part persists in the distended air spaces, but it is frequently in a state of fatty degeneration. Of most importance is the atrophy of the elastic tissue, because on this account the lung tissue will be prevented from collapsing as it normally does.

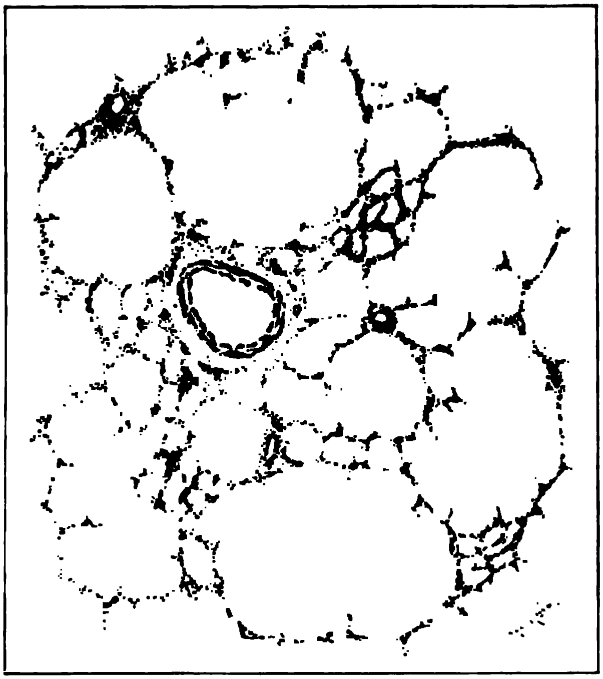

Fig. 516.—Lung in vesicular emphysema. × 50.

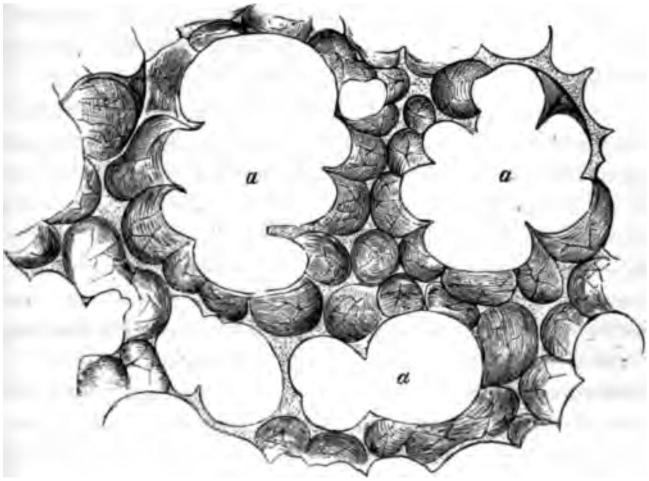

Fig. 517.—Section of the lung in emphysema, early stage. The infundibula, *a*, *a*, *a*, re dilated. × 100. (Rindfleisch.)

The lung as a whole presents alterations consistent with those in its finer structure. In general emphysema, when the chest is opened, the lungs are seen to be **bulky and pale**; they do not retract within the chest, and they give to the hand a soft downy feeling. They scarcely crepitate when handled and when pressed on the surface a pit is left. These characters are due to loss of elasticity, which renders the lung tissue less capable of retracting. The localization of the lesion is indicated by increase of bulk and change of colour, the affected parts having a light grey or pinkish colour mottled with spots and lines of pigment. Thus the **Anterior margins** are unduly voluminous, and the edges rounded. The enlargement is often somewhat irregular so that pieces are partially isolated by being specially enlarged. This applies more particularly to the **Ear-shaped piece** which projects from the anterior border of the left lung corresponding with the lower part of the heart. **The Base** also, on account of the insufficient support of the diaphragm, frequently shows marked evidences of emphysema, in the form of irregular rounded prominences, and the diaphragmatic surface of the lung may be convex instead of concave. This is especially the case in the left lung where the diaphragm is not supported by a solid organ as it is on the right side by the liver. Again the enlargement is very frequent at the **Apices**. It has been pointed out by Jenner that the right lung often presents a special bulging posteriorly at a place corresponding to the space behind the trachea.

The localization will be more various where the emphysema is complementary, and in that case will depend greatly on the locality of the cause. Thus we see it **around cicatrices** or contracted pieces of lung, but in nearly all cases there is a tendency to affect especially the anterior parts.

In all these places, with increase of bulk in general there is, even to the naked eye, a visible enlargement of the air spaces. Normally, the individual air vesicles are scarcely visible, but in emphysema the abnormal air spaces are plainly seen through the pleura, or on section, often giving a frothy appearance from the size of the vesicles and the delicacy of the partitions. Beyond this we may have all degrees of visible enlargement of the air spaces up to considerable bladders as large as an egg. On cutting into them there is often a creaking, crisp sound, and if the vesicles are large they collapse markedly.

The effects of emphysema.—The lungs are permanently increased in bulk, and the **Capacity of the chest is increased**. The chest is kept more or less in the condition of deep inspiration, the diaphragm depressed and flattened, the shoulders elevated, the sternum pushed forwards and outwards, and the chest more or less **barrel-shaped**. The eart is depressed along with the diaphragm and placed more horizon-illy, while it is overlaid by the edges of the lungs. The liver is ushed downwards by the flattened diaphragm.

Emphysema has a serious **Effect on the circulation.** We have seen iat there is obstruction and destruction of the blood-vessels in the ing, with the result of producing **dyspnœa** from insufficient passage of lood through the lungs. By the efforts of the right ventricle, which ommonly shows hypertrophy, there may, for a time, be a partial ompensation. But as time goes on the compensation is liable to ecome incomplete, and the general results of dilatation of the right entricle and general venous hyperæmia follow. The prolonged strain rill try the muscle of the heart and death commonly ensues from eart-failure, the muscular substance being not uncommonly found atty.

Senile emphysema.—This is primarily an atrophy of the lung tissue orresponding with the general atrophy of old age. When the chest s opened the lung in this form retracts and falls backwards against he posterior wall of the chest. Hence the name applied by Jenner f "small-lung emphysema." The normal weight of the lungs is about 14½ ounces in the male and 35 ounces in the female, but in senile emphysema they may be only two thirds of this weight. The air vesicles undergo changes similar in appearance to those in ordinary vesicular emphysema; their walls atrophy and the infundibula coalesce o as to form larger cavities, but this is by a simple process of atrophy. On examining the lung the increased size of the air spaces may be invisible at first, but if the lung be distended, or if after laying it open y incision it be floated in water, the large vesicles become visible. As old people are specially subject to bronchitis, senile atrophy may trongly predispose to the more ordinary form of emphysema.

Literature.—*Interlobular*—Virchow, Arch. f. wissensch. Heilk., iii.; Sachse, Virch. Arch., li., 1871; Güterbock, ibid., lii., 1871; Coats, Glasg. Med. Jour., xxv., 1891, p. 424. *Vesicular*—Lænnec, Traité d'auscult. méd., i., 348; Mendelsohn, Der Mech. der Resp. u. Circul., 1845; Gairdner, Edin. Monthly Jour., xii. and xiii., 1851; Jenner, Med. Chir. Trans., ii., 1857; Rindfleisch, Path. Hist.; Thierfelder, Atlas d. path. Hist., 1872; Hertz, in Ziemssen's Handb., v. ii; Eppinger, Prag. Vierteljahrschr. f. pract. Heilk., vol. cxxxii.; Durand Fardel, Malad. des vieillards, 1854; Fowler, in Allbutt's System of medicine, vol. v., 1898.

V.—DISORDERS OF THE CIRCULATION IN THE LUNGS.

The pulmonary circulation differs in certain important respects from he systematic circulation. The pulmonary arteries are comparatively hin-walled and the muscular coat, even in the finer branches, is but slightly developed. Hence there is little of that variation in blood-pressure which in the systemic circulation is brought about by alterations in the state of contraction of the arterioles. The pulmonary blood-pressure is normally low and is subject to little variation, except in a purely passive manner. It might be supposed that the pulmonary arterial pressure would correspond and vary with the systemic arterial pressure, but it does so to a very slight extent. The mitral valve when it is sufficient seems to cut off the systemic from the pulmonary circulation, so that there may be great elevation of the systemic blood-pressure whilst the pulmonary pressure is only slightly raised or even remains normal. Thus in asphyxia, where the systemic pressure is greatly elevated, the pulmonary is comparatively little affected. It follows from these facts, however, that pathological variations in the pulmonary circulation such as that produced by insufficiency of the mitral valve will tell greatly, as the means of compensation which the systemic arteries possess are much less efficiently present in the pulmonary arteries.

1. **Active hyperæmia.**—This is not frequently met with except as an accompaniment of inflammation or other affection of the lung. It may be produced by the inhalation of irritating vapours. A **Collateral hyperæmia** occurs when, in consequence of disease which has rapidly developed, a considerable portion of the pulmonary circulation is obstructed. In cases of pneumonia where the exudation in the lung alveoli exercises pressure on the vessels, the unaffected parts of the lung are commonly hyperæmic. Embolism of the pulmonary artery will also produce a collateral hyperæmia.

A more equivocal collateral hyperæmia is sometimes produced by the application of cold to the surface, as in bathing while over-heated, or the imbibition of large quantities of cold liquids. The effect of this is to cause great contraction of the arteries in the skin on the one hand, or the stomach and neighbouring parts on the other. T anæmia thus produced causes, when extreme, a rise of blood-pressu in the pulmonary circulation, an acutely developed hyperæmia, whi however, partakes of the nature of passive more than of act hyperæmia. There is in some such cases acute œdema, which may accompanied by hæmorrhage. (See case by Hertz.)

2. **Passive hyperæmia and Œdema of the lungs.**—In the lu as elsewhere these two conditions are often associated. Pass hyperæmia in the lungs is nearly always connected with functio disturbance of the heart, and there are two principal forms of he lesion which are apt to give rise to it. These are, on the one hand, cardiac lesions, chiefly valvular, which interfere mechanically with the

monary circulation, and, on the other hand, weakness of the heart, ch, as we have seen, is a cause of passive hyperæmia in general.

assive hyperæmia from cardiac lesions occurs under all the erent forms of heart disease in which the return of blood to the left icle and ventricle is hindered by valvular incompetence or otherwise. e under Valvular Disease of the Heart.) In mitral disease especially re is commonly a direct obstruction to the return of blood from the gs. This is, in many cases, partly compensated by hypertrophy of right ventricle, but even when it is so the pulmonary circulation l be at an increased pressure, and a more or less permanent passive eræmia will exist. This expresses itself during life in the readiness h which dyspnœa develops itself, and also in the frequent coincidence ronchitis.

he condition of the lungs in cases of prolonged passive hyperæmia xpressed in the designation **Brown induration.** The whole lung is re consistent than normal, and does not retract so fully when the st is laid open. The colour is brownish, but the depth of colour ies considerably in different cases and in different parts of the lung. this, as in other cases of prolonged hyperæmia, the connective tissue hickened and increased in density; hence the induration, which kitansky thought to be due to inflammatory hypertrophy of the nective tissue. At the same time the capillaries are greatly dilated l tortuous, and hæmorrhage by diapedesis is liable to occur as in sive hyperæmia generally. The blood escapes partly into the lung eoli, giving rise to **Hæmoptysis**, and partly into the surrounding nective tissue, producing the **Brown pigmentation.** The pigment n the form of brown granules in the connective-tissue corpuscles. mented catarrhal cells are often abundant (see Fig. 518).

he condition of the vessels is well shown by separating a piece of lung tissue by ture, then placing it in nitric acid and afterwards in alcohol. When sections made the varicose capillaries will be displayed as a brownish-red network, and larger vessels will also be seen.

ven extreme and prolonged hyperæmia may exist without the elopment of œdema, the occurrence of which will usually imply the ervention of weakness of the heart.

assive hyperæmia from weakness of the heart is commonly accom- ied by œdema of the lungs. In many cases it is developed **shortly ore death**, and is an expression of the fact that failure of the heart he immediate cause of death. In a large number of debilitating eases we find just before death the chest full of râles and the breath- much obstructed. In these cases passive hyperæmia and œdema are found after death. On the other hand these phenomena may develop in the course of diseases which specially involve the heart, more particularly **the acute fevers**, in which passive hyperæmia and œdema are frequently of serious import. Existing cardiac lesions, as already mentioned, will predispose to œdema if the heart happens to become exhausted or weakened.

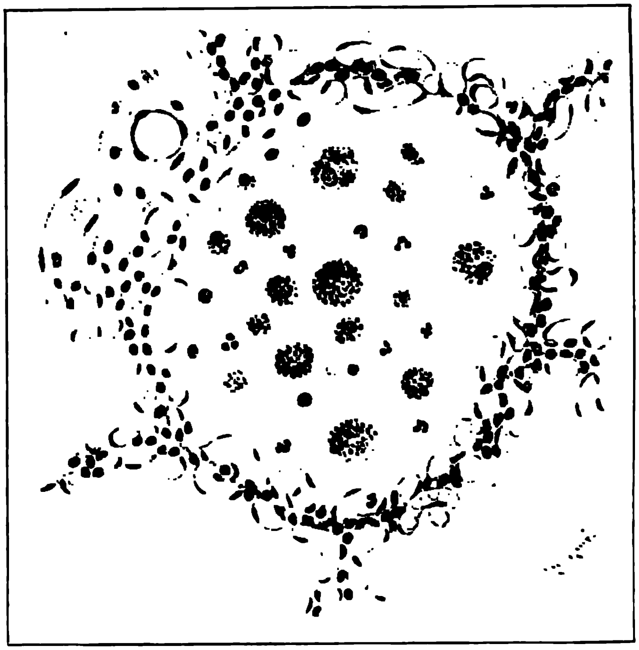

Fig. 518.—Lung in passive hyperæmia. From a case of mitral disease. × 200.

Under these various circumstances gravitation plays an important part in the development of the hyperæmia and œdema, and these phenomena are usually most distinct in the parts which during life have been the most dependent. Hence the term **Hypostatic engorgement** is often applied. As a general rule, the parts affected are the posterior and basal portions of the lungs. They present after death a dark blue colour, and the tissue is bulkier and more solid than normal. The physical condition is expressed in the term **Splenization**, the tissue resembling that of the spleen. If the lung be incised and squeezed, a frothy fluid mixed with blood issues from the cut surface. Examined microscopically it is seen that the capillaries are distended and the lung alveoli occupied by serous fluid.

postasis occurs as a post-mortem phenomenon, and this must be borne in in the diagnosis of hypostatic engorgement. Even in cases of sudden death accident the posterior parts of the lung are often of a livid colour from the before coagulation having gravitated to the parts of the lung which, in the ıbent position of the body, were dependent.

hen passive hyperæmia and œdema have persisted for a time they ı pass into a condition closely allied to **Inflammation**. Fibrine and thal cells are present in the lung alveoli, and the lung tissue be- s more and more consistent, approaching to the condition of tization. There is not, however, the complete condensation of er pneumonia, and an excess of fluid, sometimes of a thickish ıous character, exudes from the cut surface.

dema of the lungs sometimes occurs **without hyperæmia**, or at with very little evidence of the latter visible post mortem. This its of somewhat ready explanation in cases of Bright's disease, e it is related to the general tendency to œdema. A simple na may also occur in consequence of multiple fat embolism in the . In other cases there is no apparent cause other than failure of heart, and the absence of hyperæmia may be due to a general nia or to some local conditions such as pleural effusion.

cases of simple œdema the lungs are pale and look bulky. On ion clear frothy fluid exudes, sometimes in large quantity.

ınheim has endeavoured to elucidate the pathology of œdema of the lungs periment in animals. An extreme passive hyperæmia may be produced by yzing the left ventricle, while the right ventricle retains its full powers. heim supposed that a weakening of the left ventricle might explain the æmia and œdema occurring immediately before death. This explanation not seem to the author to be a likely one. Great hyperæmia exists in cardiac ıs, produced in a somewhat similar fashion to that in these experiments, ly, by obstruction on the left side of the heart, without any œdema, unless is a failure in the cardiac contractions. It seems to be rather the extreme ation of blood, which such failure implies, that determines the œdema.

erature.—Bradford, Dean, and Lewis (*Pulm. circulation*), Proc. of Roy. Soc., ; Rokitansky, Lehrb., iii.; Zenker, Beitr. z. norm. und pathol. Anat. d. en, 1862; Cohnheim, Allg. Path., i., 501, 1882.

Embolism of the pulmonary artery.—The pulmonary artery is ably more liable to embolism than any other vessel. The embolus be derived from thrombi in the right side of the heart or in the s: it may consist of fat, or it may have origin in tumours or sites which have penetrated the veins.

a considerable proportion of cases the hæmorrhagic infarction ts, but by no means in all (see p. 89). In the case of **Fat** **lism** there may be many small hæmorrhages with œdema, or even a more considerable area of hæmorrhage. (See p. 92 and Figs. 27 and 519.)

There are many cases of pulmonary embolism without any development of the infarction, and, it may be, without any pronounced appearances at all. If the embolus be large enough to obstruct the main artery of the lung, then there can be no hæmorrhage, as the whole lung is cut off from its blood supply through the pulmonary artery. When smaller branches are occluded, the infarction may be absent. Cases of sudden death after parturition occur from embolic obstruction of the lungs without any infarction. The suddenness of death in some of these cases seems to indicate that it is not due entirely to the obstruction in the lungs and consequent non-aëration of the blood. It seems rather due in great measure to the fact that, as the blood is prevented from reaching the left ventricle in sufficient amount, the brain and medulla oblongata are deprived of their proper nourishment. In such cases the right ventricle will be found dilated, while the lungs are pale and probably over-inflated by the violent but ineffectual respiratory efforts. These sudden deaths after confinement used to be ascribed to shock before Virchow pointed out their true significance.

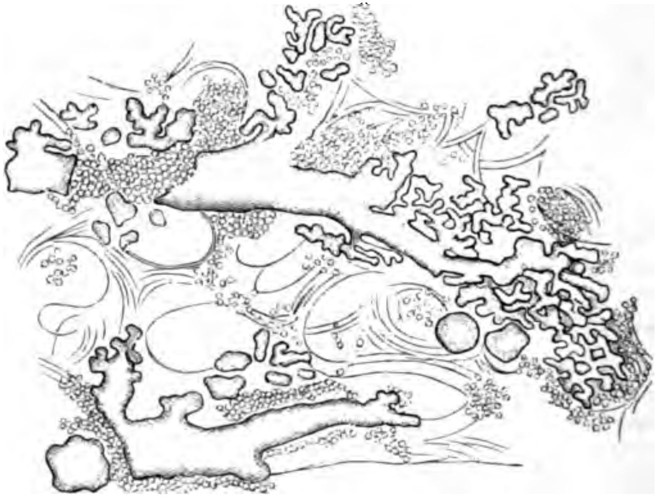

Fig. 519.—Oil or fat embolism of lung. The fat occupies the smaller arteries and extends into the capillaries which, towards the right, form a network injected with oil. (THIERFELDER.) × 90.

4. **Pulmonary hæmorrhage.**—Hæmorrhage occurs in the lungs under a considerable variety of circumstances and presents many different appearances.

The **Hæmorrhagic infarction** is the form most frequently met with after death. It results from obstruction of the pulmonary artery, and this is in the great majority of cases due to embolism, but in a few may be the result of thrombosis. In cases of extreme passive hyperæmia, re may be such stagnation of the blood in the pulmonary artery in ne parts as to induce coagulation, but this is very rare.

The pulmonary artery in itself and its branches is an end-artery, but rious local circumstances frequently interfere with the formation of the arction. The capillaries of the lung are wide, and may act in the ne way as anastomosing vessels so as to keep up the circulation and event engorgement. In addition, the bronchial artery nourishes the ng tissue and even forms communications with the pulmonary artery. e infarction is least likely to occur where the affected piece of lung sue is completely surrounded by lung tissue whose capillaries com-unicate. The existence of the pleura at one or several surfaces will terfere with such communication, and hence the infarction is more mmon at edges, where two or three surfaces are covered with leura, than in the substance of the lung or at its lateral and posterior pects.

The observation of Pitt confirms these statements in so far that blocking of e pulmonary artery is frequent without the occurrence of the hæmorrhagic in-rction. This author asserts, in opposition to Cohnheim, that thrombosis of the ulmonary artery is a frequent lesion.

The hæmorrhagic infarction presents itself as a limited piece of con-ensed lung tissue, which may be often recognized by its dark colour een through the pleura, but is more easily discovered by handling the ng, when the solid mass is readily detected. It is more or less edge-shaped, the base being at the surface. It is usually peripheral nd most frequently at an edge of the lung (see Fig. 520). It presents reat varieties in size up to nearly half the lung, but it is most mmonly of moderate dimensions. When recent, the infarction oks on section like a recent blood clot, and has almost a similar nooth surface, from which circumstances the term **Pulmonary poplexy** used to be given to the condition from the analogy of emorrhage in the brain, which produces cerebral apoplexy. As me goes on the colour merges into brown, and the appearance ay come to resemble that of red hepatization. As blood fills the ir spaces the piece of lung is more bulky than that surrounding t. The infarction, therefore, is often seen as a rounded bulging eneath the pleura, or, when the lung is divided it stands at a higher evel than the surrounding tissue. The pleura over the infarction is sually covered with a layer of fibrinous exudation of a yellow colour, nd the pleural cavity contains fluid, often in considerable quantity.

Search should always be made for the obstruction in the artery. he arteries in the infarction itself may be filled with coagulum, but he plugging generally extends beyond its apex, the actual embolus being usually some little distance on the proximal side of the infarction. (Fig. 520.) An endeavour should also be made to find the source of the embolus.

Under the microscope, the affected parts of the lung show, as in Fig. 521, an enormous aggregation of red blood-corpuscles in the lung alveoli and finer bronchial tubes, with distension of the pulmonary capillaries.

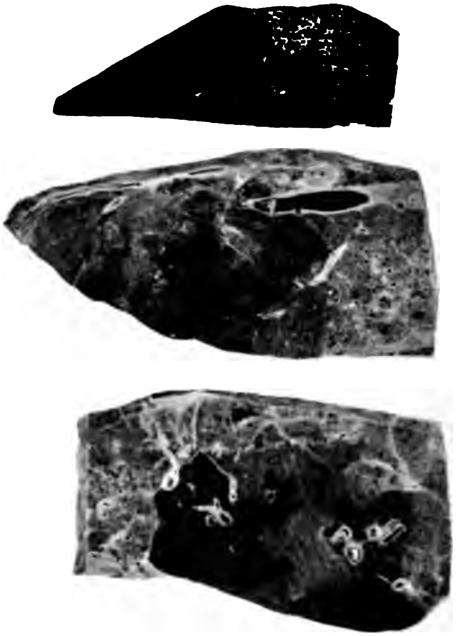

Fig. 520.—Three hæmorrhagic infarctions of the lung, showing the obstructed arteries on section.

The absolute filling out of the alveoli with blood to the entire exclusion of air indicates that there has been a leakage from the capillaries gradually filling up the alveoli and expelling the air. There is usually hardly a trace of fibrine to be seen, merely red blood-corpuscles which have escaped by diapedesis, and some catarrhal cells. Such cells are nearly always present, the blood irritating the epithelium and inducing their production.

If the patient live for some time after the occurrence of the infarction certain changes occur in it, but there are few actual observations bearing on this point. A case observed post mortem by the author gave definite indications as to the course of events. The symptoms during life indicated the formation of an infarction months before death. The conditions observed were those of partial recovery from the lesion. The pulmonary tissue was brown and partly condensed in a limited area. The artery supplying this area showed a plug consisting of connective tissue formed by the process of organization described at p. 83. The circulation had been partly restored by this process. It is apparent from this observation that in some cases the infarction clears away; the blood is discharged by expectoration, and the circulation is re-established, but the portion of lung is unduly pigmented. In other cases the portion of lung gradually shrinks, and the ultimate result is a pigmented induration. Indurations, probably of this origin, are not infrequently met with in cases of valvular disease. In other cases, again, the portion of lung tissue dies and sloughs, so that a cavity forms. Sometimes the slough decomposes, and we have all the features of gangrene of the lungs. It may seem strange that necrosis, which is the regular result in other organs, is not of more constant occurrence in the lungs. It is to be remembered, however, that the lung tissue in the midst of the infarction is still nourished by the bronchial artery,

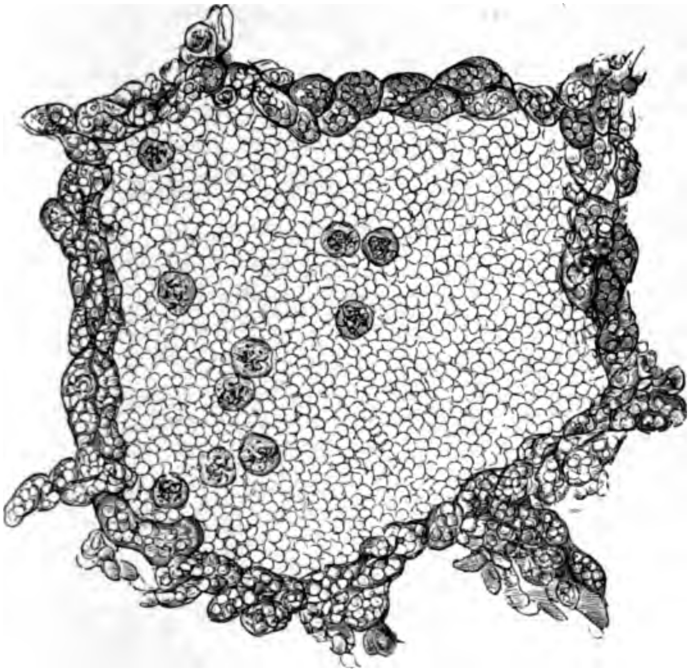

Fig. 521.—From a hæmorrhagic infarction of the lung. The alveolus is filled with red blood-corpuscles, with one or two large catarrhal cells. In the wall of the alveolus the capillaries are greatly distended with blood. × 350.

and that, while the capillaries and actual walls of the alveoli may die, the interlobular connective tissue may survive, and may even use the necrosed tissue as pabulum.

Conditions resembling in general and microscopic appearances the hæmorrhagic infarction occur in extreme cases of passive hyperæmia. This is not surprising as the infarction is itself the result of stagnation of blood. But the hæmorrhagic condensations produced by passive hyperæmia have not the locality or limitation of the proper infarction.

There are also hæmorrhages in scurvy, hæmophilia, hæmorrhagic small-pox, etc. Hæmorrhage is very frequent in phthisis pulmonalis, as will be subsequently described. It is asserted also that there may be rupture of a branch of the pulmonary artery from fatty degeneration of its walls, as we may have hæmorrhage in the brain from atheroma, but this is excessively rare.

Hæmorrhage is not uncommon from **Tearing or Rupture of the lung**, by a penetrating instrument or a broken rib. The blood in this case will partly escape into the pleura, but it will also collect in the cavity torn in the lung and infiltrate neighbouring parts of the parenchyma. According to Rokitansky blood thus effused may be encapsuled and subsequently infiltrated with lime salts like a foreign body.

When the hæmorrhage is from the bronchial mucous membrane or the lung alveoli, then it appears in the sputum. To some extent, however, the blood remains in the air passages, and if it be in considerable quantity it may even be carried by **Insufflation** into the lung alveoli. The blood, in this case, is mixed with air, and there is no such condensation as that which occurs in the hæmorrhagic infarction. In the lung alveoli the blood acting as a foreign body irritates the tissue and a catarrhal inflammation may result. In such cases large catarrhal cells occupy the alveoli abundantly wherever the blood has penetrated, and these cells may be deeply stained with the colouring matter of the blood.

Literature.—ROKITANSKY, Lehrb., iii.; ZENKER, Beitr., zur norm. u. path. Anat. d. Lungen, 1862; HERTZ, in Ziemssen's Handb., v.; COHNHEIM, Allg. Path., 1882, i., 501; GERHARDT, Volkmann's lectures (Syd. Soc. transl.), 1876, 2nd ser., p. 261; PITT, Path. Trans., xliv., 1893; FUJINAMI, Virch. Arch., clii., 1898; SCRIBA (Fat Embolism), Deut. Zeitsch. f. Chirurgie, 1879, B. xii., § 110 (literature).

VI.—INFLAMMATIONS OF THE LUNG.

The inflammations of the lung vary considerably according to cause, distribution, and the structures specially affected. The irritant which leads to the inflammation may have its seat primarily in the bronchi, in the lung alveoli, or in the pulmonary arteries. In the first case it l probably happen that the agent will affect certain bronchi and ir connected alveoli so as to produce a **Lobular** distribution. In : second case there may be a general diffusion over a wide tract lung, such as a whole lobe or more, so as to give a **Lobar** disɔution, whilst in the third case there is likely to be an **Embolic** tribution.

The character of the inflammation will depend on the nature of the itant as well as on its distribution. We have acute inflammations, th excessive exudation, sometimes going on to suppuration; and we ve chronic inflammations with new-formation of connective tissue. e have also inflammations mainly affecting the lining membranes of onchi and alveoli, and others involving the deeper structures. In arly all inflammations the epithelium of the alveoli is more or less volved. In acute inflammations it is soon shed, while in the chronic rms it proliferates and yields large cells (catarrhal cells) which may cumulate in the alveoli.

The chief forms of inflammation may be considered under four adings, namely, acute lobar pneumonia, acute broncho-pneumonia, ıbolic pneumonia, and chronic or interstitial pneumonia. In phthisis lmonalis many of the lesions are inflammatory, but, as we have here rue tuberculosis, the inflammatory manifestations will be considered ng with the tubercular.

1. **Acute lobar pneumonia** (*Croupous pneumonia*).—This is essentially disease of the lung alveoli, and the most prominent feature is an udation of fibrine, from which the name croupous pneumonia is rived.

Bacteria of pneumonia.—Pneumonia is caused by virulent pathonic bacteria, but the same microbe is not always the infective agent. some cases of secondary pneumonia, the ordinary pyogenic micrococci ıve been found, but in primary cases one or other of two distinct rms can in the great majority of cases be detected. These are the iplococcus or Pneumococcus of Fraenkel, and the Pneumococcus, or ıore correctly the Pneumobacillus, of Friedländer. Weichselbaum und, in 83 cases, the former 54, and the latter 6 times.

(*a*) **Pneumococcus of Fraenkel. Diplococcus pneumoniæ. Capsuleoccus.**—This microbe, the pathogenic characters of which were first istinguished by Fraenkel, has, apart from pneumonia, pathogenic elations of wide extent. It is not only the prevalent microbe in neumonia, but it has been frequently observed as the infective agent n acute lepto-meningitis, whether the epidemic, sporadic, or traumatic ɔrm, also in otitis media, in ulcerative endocarditis, in acute nephritis, n acute synovitis affecting several joints, in abscess, etc.

It has the form of a slightly elongated coccus, and generally two are united together (Diplococcus); sometimes it occurs in longer chains. When found in the animal body it is surrounded by a **capsule** (see Fig. 522), but in cultures it loses this. It is readily stained by ordinary aniline dyes, and when so treated the capsule appears as a faintly coloured halo around the microbe. The microbe stains by Gram's method, but its capsule is not visible. It is readily cultivated on nutrient media, but requires a temperature over 22° C., and grows best at 35° C. The cultures quickly lose their virulence and readily die.

The microbe is highly virulent in rabbits, less so in mice and guinea-pigs. If cultures are subcutaneously injected into a rabbit, an acute febrile disease is produced, of which the animal dies in one or two days. The capsule-coccus is found in enormous numbers in the blood.

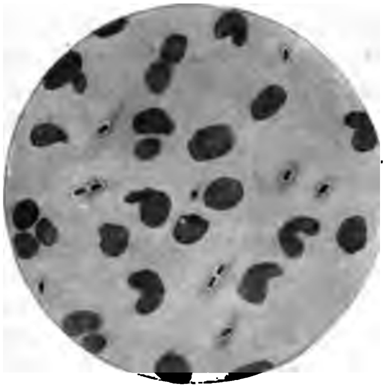

Fig. 522.—Capsule-coccus from exudation in case of lepto-meningitis. × about 1000.

Immunity has been produced in rabbits in various ways, as by injection of the toxins, and the blood serum is stated to confer immunity on other animals. The blood serum of patients who have recovered from pneumonia confers a transient immunity on rabbits.

An exceedingly interesting fact is that the **Sputum of healthy persons** frequently contains the capsule-coccus. The secretion of the mouth in such persons when inoculated subcutaneously in rabbits produces the regular form of disease (Sputum-septicæmia).

(*b*) **Bacillus pneumoniæ. Friedländer's Pneumococcus or Pneumobacillus.**—This somewhat resembles the former, but is longer, and hence is a bacillus. It also possesses a capsule, but only when obtained in the living body. It is non-motile. It grows on the ordinary culture media, and does not require a temperature above that of an ordinary room. In this respect it differs from the diplococcus, as well as in the fact that it does not stain by Gram's method.

It is not pathogenic in rabbits, forming thus a striking contrast to the capsule-coccus. It is pathogenic in mice and dogs, less so in guinea-pigs.

The bacillus of Rhino-scleroma, as we have seen (p. 817), closely resembles the bacillus pneumoniæ of Friedländer, and like it possesses capsule. In its appearance in cultures and pathogenic relations to imals, it is virtually identical with the bacillus of pneumonia, and probably a variety of the latter.

Causation.—Certain forms of microbes, of which the diplo- ccus of Fraenkel is the chief, are the active agents in pneumonia. hese microbes are often present in enormous numbers in the exudation ntained in the lung alveoli. The fact that the diplococcus is fre- ently present in the normal sputum, and consequently in the lung, ints to the existence of other contributing causes. It is probable at certain conditions, such as exposure to cold or a preceding attack f true influenza, may aid the specific microbe and enable it to overcome e resistance of the tissues.

Pneumonia is to be regarded as one of the acute specific fevers in hich the infective agent has a local seat. The lungs present the ore direct effects of the agent, but the general febrile disturbance is linically the more important part of the phenomena. The fever has a listinct periodicity, and, consistently with this, there is an antitoxin roduced, which has the power of conferring immunity (see pp. 146, 147).

Many epidemics of pneumonia have been observed in various quarters of the lobe (see Hirsch). It is an interesting fact that occasionally epidemic outbreaks f fever of peculiar and unusual characters have been associated with acute neumonia. Amongst these may be mentioned an epidemic which occurred in n industrial school in Glasgow, which in some of the earlier cases caused death ithin twenty-four hours of the onset, and which, in many of the cases which ived for a longer period or survived, was accompanied by a typical pneumonia. This epidemic could not be referred to any of the recognized forms of fever (see ussell). Strain has also described an epidemic of pneumonia in South America, nd Stevenson in India.

The disease is an acute inflammation, and as the lung alveoli ossess merely a single layer of pavement epithelium which is soon lesquamated, the inflammation resembles that of serous rather than of nucous membranes. As in the former we have here a fibrinous xudation, and, though this occurs primarily and mainly in the alveoli, he fibrine, as we shall see, generally extends to the finer bronchi, orming casts of them.

Pneumonia is divisible into several stages, which, however, to some xtent merge into each other.

In the first stage, that of **Engorgement**, there is an active inflammatory hyperæmia; the lung capillaries are highly injected, and there is an exudation of serous fluid into the air vesicles. To the naked eye the affected portion of lung is of a dark red colour, to the touch it is inelastic, and the finger applied to the surface leaves a pit behind. On section a reddish serum flows out, and the tissue does not crepitate under the knife so much as in the natural state. This state, from the resemblance of the cut surface of the diseased lung to the spleen, has been called **Splenization.** So far as the merely anatomical condition is concerned the lung is very much in the same state as in passive hyperæmia and œdema, to which also the term splenization is applied. In pneumonia, however, the splenization is not localized in the dependent parts, but it affects a definite region of lung, generally the lower lobe as a whole, along with, perhaps, a portion of the upper. Like other inflammatory exudations, the serous fluid contains leucocytes and also red blood-corpuscles, sometimes in large numbers. As the alveoli are filled with serous fluid, the air, bubbling in and out among the fluid during respiration, produces the fine crepitation which is the characteristic auscultatory sign o this stage.

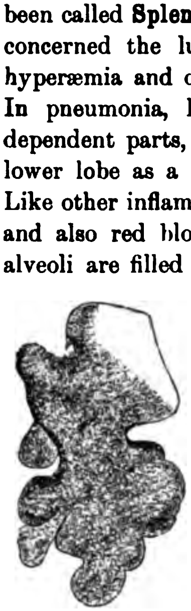

Fig. 523.—Cast of a small bronchus, infundibula, and air vesicles in pneumonia. × 40. (Cornil and Ranvier.)

In the second stage, that of **Red hepatisation** we have fibrine deposited in the alveoli. In consequence a coagulum (Fig. 523) comes to occupy the lumen of the vesicles and infundibula, instead o the mixture of serous fluid and air which is presen in the first stage. The coagulum, like the fluid contains abundant leucocytes and some red corpuscles, the former often so abundantly as almost to conceal the fibrine. The fibrine may be detected as a coarse network of interlacing fibres (Fig. 524). The capillaries of the lung are in much the same state of over-distension as in the first stage; the lung parenchyma is little altered.

On microscopic examination of an ordinary section of the lung in this stage the lung alveoli are found to be occupied by solid plugs, to the entire exclusion of the air, as in Fig. 525. On closer examination of an unstained section, or by means of special staining, the fibrine will be detected as in Fig. 524.

The red corpuscles are present in the alveoli in very varying proportion. They are never entirely absent, but they form generally the minority of the total cells present; in some cases they are equal to the leucocytes, in some more abundant. In very rare cases they are so abundant that the exudation has more the character of an ordinary clot than of a fibrinous exudation. In these latter cases, which may be described as **Hæmorrhagic pneumonia**, the lung as a whole or in part has a deep red colour. These are mostly very severe cases, and imply a previous state of debility in the patient, very commonly referable to alcoholic excess. In accordance with this exudation of red bloodpuscles we have, in this and in the preceding stage, the rusty tinge the sputum which is characteristic of pneumonia.

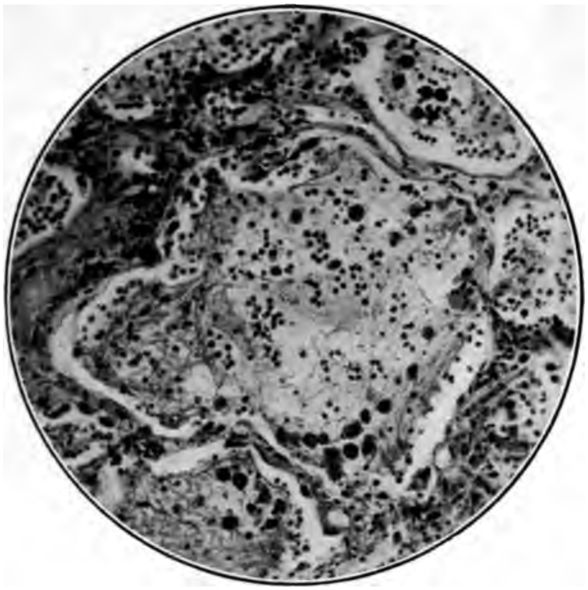

Fig. 524.—A lung alveolus in acute pneumonia.

The appearance of the lung in this stage is somewhat different from t in the first. It retains its red colour, both from the continuance

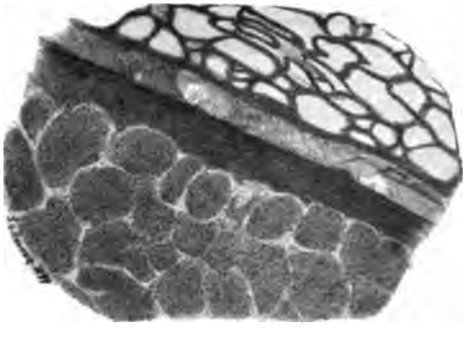

Fig. 525.—Hepatization of lung. The section is made so as to include part of the hepatized lower lobe and unaffected upper lobe, with intervening pleural surfaces. The latter are coated with fibrine from the usual acute pleurisy. × 100.

he congestion of the capillaries and from the red corpuscles in the dation, but it is now much firmer and heavier—it does not crepitate der the knife or finger, and it sinks in water—no air being any longer contained in the vesicles. On section from a sound part into a hepatized part, it is observed that the latter remains on a level while the sound part sinks away, so that the diseased part appears enlarged. Even on external examination the affected part of the lung looks bulky, and on closer examination, the cut surface has not the homogeneous velvety character of the lung in splenization, but a coarse granular appearance. This is more readily seen on tearing the tissue and examining the torn surface with a lens. The granulations thus brought out are undoubtedly the plugs of fibrine with corpuscles which fill the air vesicles. On stroking the cut surface with the blade of the knife casts of the vesicles and infundibula may be obtained (as in Fig. 523). The finer bronchial tubes when laid open are generally found to contain casts of soft fibrine, as if the exudation had overflowed from the alveoli into them. The appearance of a section of such a lung has been compared, from its solid character, granular surface, and colour, to that of the liver, hence the name hepatization applied to this stage.

The solidified lung is a much better conductor of sounds than a lung filled with air; hence, during life, we hear the sounds of the trachea and bronchi much more distinctly than usual: it is almost as if one put the stethoscope over the trachea itself.

The third stage, that of **Grey hepatization**, develops naturally out of the second. In the earlier periods red corpuscles are exuded largely, except in cases of a hæmorrhagic kind the white very much preponderate, but especially in the later periods. The leucocytes swarming into the alveoli distend them more and more. The additional material in the vesicles also causes pressure to be exercised on the capillaries, which are thereby emptied. In this way we have, instead of the previous hyperæmia, an anæmia of the tissue. In accordance with the smaller number of red blood-corpuscles and the presence of an additional number of colourless cells, the colour of the tissue is changed. It retains the firm character, and the granular appearance of the previous stage, but the colour is grey (see Fig. 526). The pigment of the lung intermixed with the white colour of the multitudinous cells gives the appearance which has been aptly described as marbled. When pneumonia develops in a lung the seat of emphysema the appearances above described are often very well marked (see Fig. 527).

It is not to be supposed, however, that during life the vessels are empty. It is always possible to inject the vessels after death, and during life no doubt the force of the heart is sufficient to keep up the circulation. We are, therefore, scarcely warranted in saying that the grey colour of this stage is anything but a post-mortem appearance.

In the last stage, that of **Resolution**, the lung returns to its normal tion. The cells and fibrine in the air vesicles undergo fatty de-ation, and the plugs soften. Even in the stage of grey hepatization ucocytes and fibrine have begun to undergo fatty degeneration, this process advances in the stage of resolution. The fatty eration and disintegration of both cells and fibrine result in the

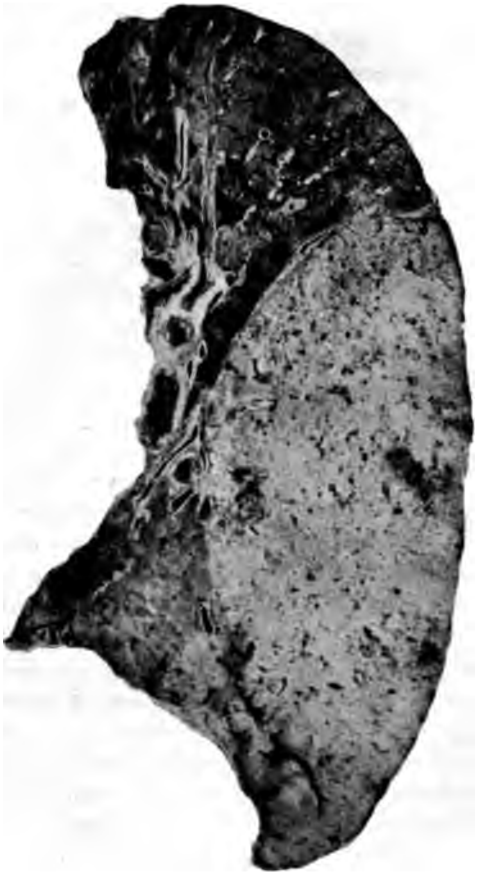

Fig. 528.—Grey hepatization of the lower lobe of the left lung.

sion of the exudation into an emulsion which fills the alveoli, aving a yellow or greyish-brown turbid appearance, resembles its naked-eye appearances.

lung is still solid, still sinks in water, but its firmness is gone; face is pale, yellowish, or greyish red; it has lost the granular ance, and a greyish, dirty fluid oozes out, which makes the surface so slippery that a small portion is with difficulty lifted or held in the fingers. The tissue is also extremely soft, and readily tears under manipulation. In removing such a lung from the body, unless care is exercised, pressure of the fingers may rupture the tissue, and as the pus or emulsion flows into the cavity it may give rise to the appearance of abscesses in the midst of the lung.

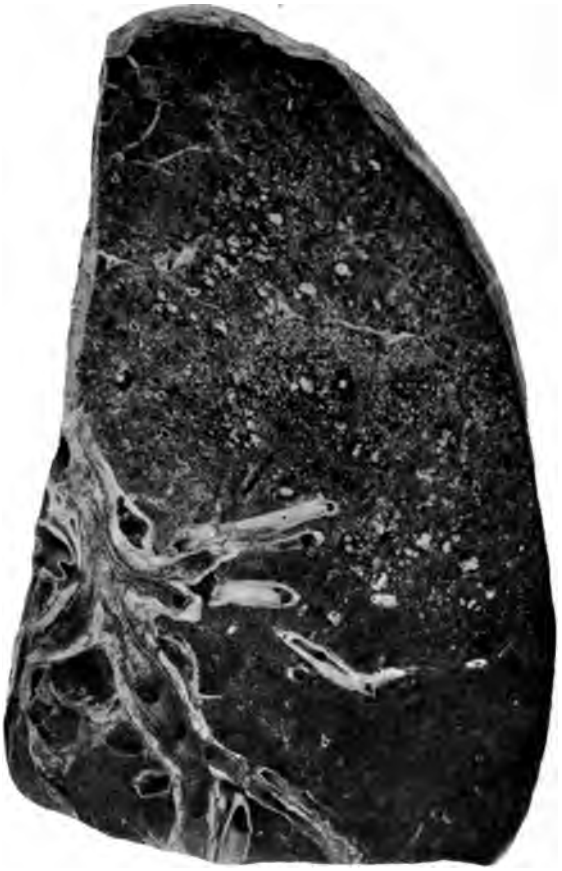

Fig. 527.—Acute pneumonia in the stage of grey hepatization in an emphysematous lung.

The softened exudation is now in a condition to be disposed of, and this is done partly by expectoration, but chiefly by absorption. The exudation must have been thoroughly softened before it will make its way through the narrow neck of the infundibulum into the bronchus, and the fatty emulsion is for the most part absorbed. It is remarkable how rapidly an extensive exudation in the lung may be disposed of.

metimes, in the course of four or five days from the crisis of a pneu- mia, the physical signs will indicate an approach to complete disposal the exudation and return of air to the alveoli, and this may be almost tirely by absorption, little expectoration occurring in the interval. some cases, however, expectoration materially aids in the disposal the exudation.

After the infundibula and vesicles are emptied the blood returns in ll force into the capillaries. Instead of the anæmia we have indeed a peræmia, for the tissue has been weakened by the inflammation, and less able to resist the blood-pressure than formerly. It should be membered in practice that the lungs of a pneumonic patient take me time to recover from the effects of the inflammation, and great ertion during convalescence should be warned against, till the tissue s recovered its tone.

Purulent infiltration is a termination of pneumonia which is rarely t with as compared with resolution. In some cases, instead of the lammation ceasing, it goes on in its acute form, and leucocytes ntinue to be exuded. In this case, when the fibrine breaks down, place is taken by pus, and a true purulent infiltration occurs. The ndition somewhat resembles that present while resolution is in pro- ess, the fatty emulsion in that case resembling pus in its naked-eye aracters.

The purulent infiltration in some cases results in **Abscess**, of which re may be several present. There may be rupture of a considerable ssel in the wall of such an abscess and profuse hæmorrhage. The scess may subsequently burst into a bronchus or the pleura, in the ter case producing empyema, and perhaps pneumothorax.

Another unfortunate result which sometimes occurs is **Gangrene** of e lung. This is mostly met with in the hæmorrhagic form and in unkards, but it may occur where, in addition to pneumonia, there is bronchiectatic cavity with decomposing contents.

Another rare result is **Chronic pneumonia**, the description of which lows below.

The **Pleura** always takes part more or less in the inflammation of e lung (see Fig. 525). The pleural surface of the inflamed portion the lung is coated with a white fibrinous exudation, which is some- nes of considerable thickness. There is rarely any considerable ous exudation in the pleura, probably because the lung distended th the solid exudation fills the cavity, and by its pressure prevents e accumulation of fluid. Sometimes the pleural exudation takes on purulent character, and an empyema may remain after the resolution the pneumonia. In some cases the inflammation extends to the pericardium, on the surface of which there may be a slight fibrinous exudation.

When resolution occurs the pleurisy will become chronic and the fibrinous exudation will be gradually absorbed. The result will usually be coalescence of the two pleural surfaces, *i.e.* adhesion of the pleura.

Pneumonia being an acute febrile disease, produces secondary changes in the organs of the body resembling those in acute specific fevers. There is commonly, but not always, enlargement of the spleen. The liver is usually enlarged, and shows parenchymatous infiltration. **Herpes** of the lips is very frequent, this condition being probably due to the action of the toxin on the nerve stems concerned.

In some cases of pneumonia the connective tissue of the mediastinum and subpleural tissue are the seats of inflammatory œdema, which may extend to the loose tissue between the œsophagus and trachea, up to the retropharyngeal tissue, the soft palate, the tonsils, and even to the nares. Sometimes this inflammation assumes a phlegmonous character. This probably occurs by propagation of the specific microbe in these loose tissues (Weichselbaum).

2. **Acute broncho-pneumonia** (*Catarrhal pneumonia, Capillary bronchitis*).—This disease occurs most frequently in children, and is in them, as in adults, associated with catarrh of the finer bronchi. The bronchi are first affected, and so it may be said that the pneumonia springs out of a **Capillary bronchitis**, the tubes affected being those of the finest calibre. In a large proportion of cases the bronchitis originates in measles, or it results from diphtheria, small-pox, or whooping-cough. In adults it may follow typhoid or other infectious fever, or it may be the result of the inhalation of irritating gases. In influenza broncho-pneumonia is very common, and in some cases may lead to gangrene of the lung.

It may be noted that an ordinary bronchial catarrh, such as was described in the section on bronchitis, seldom goes on to a catarrhal pneumonia, but that for the most part the latter is due to the existence of some special irritant such as the virus of measles.

As the disease begins in the bronchial tubes, and is propagated to the lung tissue, it follows in its distribution the arrangement of the bronchial tubes; that is to say, it occurs in a lobular form, hence the name **Lobular pneumonia** which is frequently used. Although the disease is thus primarily lobular, it is clear that it will often occur in several neighbouring lobules, and so a considerable tract of lung may be involved.

The inflammation manifests itself by the production of an exudation mingled with cells, so that the fine bronchi and the connected alveoli become filled. There is thus brought about a lobular condensation.

The cells produced are partly leucocytes and partly catarrhal cells, the derivatives of the epithelium (see Fig. 528). The proportion of each of these will depend somewhat on the acuteness and nature of the irritant, but in acute cases each minute bronchus will often contain a small drop of pus. In addition to these cells fibrine and red blood-corpuscles are frequently present in the lung alveoli. The affected pieces of lung are firm and reddish brown or grey, and on the cut surface stand above the general level. Even when a considerable district is affected the lobular appearance is usually visible.

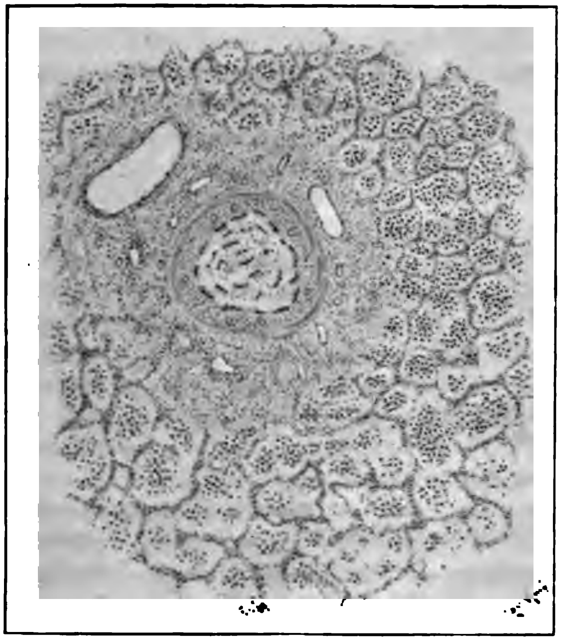

Fig. 528.—Acute broncho-pneumonia. × 50.

As the disease begins in a catarrh of the finer bronchi, there is often **Collapse** of the corresponding portion of lung even before any actual inflammatory process has occurred. The obstruction of the tubes with tough secretion sufficiently accounts for this collapse (see p. 847). It is a lobular collapse, and, as seen from the surface, areas of larger or smaller size are depressed and of a bluish red colour. These are mostly to be found, in the first instance, at the posterior and inferior parts of the lung. In other parts, and especially in the upper lobes, we may have emphysema.

The inflammation does not confine itself to the bronchi and alveoli, but may extend to the **connective tissue of the lung** generally. In such cases the exudation in the bronchi is composed of leucocytes, and cells of a similar character infiltrate the bronchial wall and neighbouring structures, the bronchi evidently forming centres of irritation.

In many cases **Acute pleurisy** accompanies the process in the lung.

The inflammatory products in the air vesicles may after a time undergo fatty degeneration, break down, and be discharged, some part of them being probably absorbed by the lymphatics. In some cases, however, the result is not in every part of the lung so fortunate. For one thing, the collapsed portions may remain uninflated, and, as considerable tracts of lung may be affected, marked shrinking of the lung and deformity may result. Or, again, the catarrh may become chronic, and, being associated with an interstitial inflammation, result in a permanent induration, the alveoli being encroached on by the growing connective tissue, as in the case of chronic pneumonia. In this way, the person, though recovering, emerges from the disease with a damaged lung; according to the extent of the permanent damage will be the shrinking of the lung and possible displacement of organs. Again, phthisis pulmonalis may develop out of an acute catarrhal pneumonia, but this is fortunately an unusual result.

It has already been mentioned that the disease begins in the bronchi, and it has been asserted by Buhl that, throughout, the inflammation remains confined to the bronchi, the inflammatory products found in the alveoli being simply insufflated from the bronchi. This view, however, can hardly be maintained, as evidence of acute changes can actually be observed in the epithelium of the alveoli.

3. **Septic broncho-pneumonia.**—This name is applied to conditions in which the bronchial tubes contain decomposing matters, which irritate the bronchial wall and the corresponding lung parenchyma. There is, as in the preceding form, a lobular pneumonia, and the histological changes are somewhat similar, although with a greater tendency to suppuration.

The circumstances under which the bronchi contain acrid contents are somewhat various. Thus **division of the pneumo-gastric nerve** in animals leads to stagnation of the secretions of the bronchi and to broncho-pneumonia. Similarly we sometimes have this condition in persons who have been long unconscious from disease of the brain, and in whom the bronchial secretion stagnates. In cases of bronchiectasis also there is often a great accumulation of putrid juices in the dilated bronchi, which may give rise to inflammation. Gangrene of the lungs and the presence of foreign bodies in the bronchi are also occasional causes of the condition under consideration. In these cases the putrid atters are sometimes carried inwards into the finer bronchi by the spiratory current, and the resulting lobular pneumonia may be at rts distant from the original lesion. In such cases the name **Insuffla- on pneumonia** is sometimes applied (see Fig. 529). In new-born ildren there is sometimes a broncho-pneumonia brought about by the sufflation of the amnionic fluid of putrid fluids from the aternal parts.

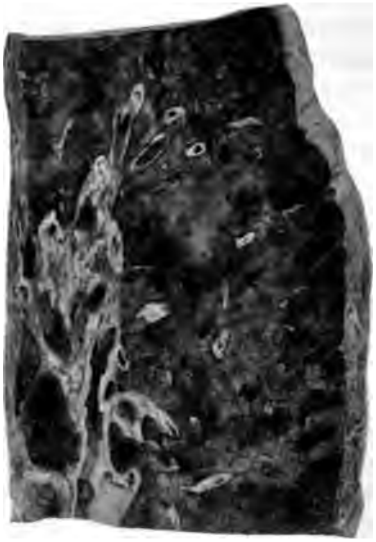

Fig. 529.—Insufflation pneumonia.

4. **Diphtheritic pneumonia.**— many cases of diphtheria the udation extends down the onchi even to their finest mifications, and sometimes also the lung alveoli. The bronchi ntain casts which do not gene- lly obstruct the calibre entirely. ese casts consist of fibrine and ucocytes, the latter in great undance. Sometimes the finer onchi generally are filled with ucocytes. There is also exuda- on of leucocytes, but not usually fibrine, into the air vesicles. is extension is from the pene- ation of the bacillus diphtheriæ into the lungs. Although there is great exudation of leucocytes these do not englobe the bacilli as ey do the pneumococcus. The bacillus diphtheriæ is taken up by e epithelium of the alveoli (Flexner and Anderson).

5. **Embolic pneumonia** (*Pyæmia or Metastatic abscesses*).—In cases of ptic thrombosis of veins (thrombo-phlebitis) in connection with wounds abscesses, a septic embolism is liable to occur, in which the lungs are ost directly involved. Pieces of the thrombi containing pyogenic icrobes (generally staphylococcus pyogenes aureus) are carried to the ng and are caught in the small arteries or capillaries.

Each such embolus becomes a centre of acute inflammation, going on ually to suppuration and gangrene. If a considerable branch be structed there may be at first the regular hæmorrhagic infarction. ut soon there is such an abundant exudation of leucocytes that the d colour is obscured, and the result is an area of grey hepatization. similar grey hepatization will develop if there has been no hæmor- age. The patch will be wedge-shaped or round according to the essel affected. The grey hepatization gives place to a purulent infiltration, usually with gangrene of the lung tissue and the regular formation of an abscess.

Such metastatic abscesses are very various in size, form, and number. If the embolism be capillary there may be multitudes of minute abscesses, but very often there are only a few which may be of considerable size.

If an abscess be near the surface it gives rise to an acute pleurisy which is apt to be suppurative in character. This may occur without the actual bursting of an abscess into the pleura, the microbes propagating through the inflamed wall into the pleural cavity (see Fig. 530).

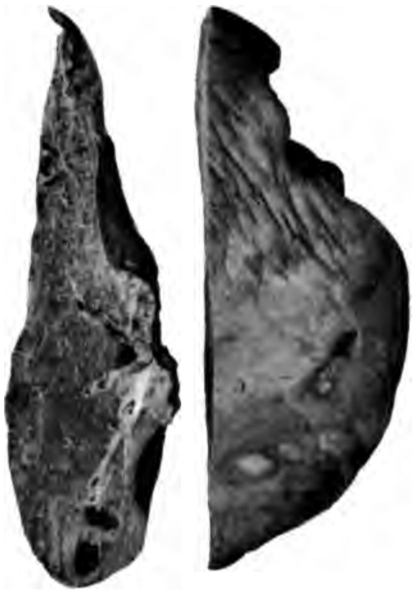

Fig. 530.—Metastatic abscesses in the lung with necrosis of the pleura.

6. **Chronic pneumonia** (*Interstitial pneumonia, Simple cirrhosis of the lung*).—We include here those conditions in which the lung tissue is the seat of a simple chronic inflammation, without anything of a tubercular or other specific nature. The simplest cases are those in which an acute pneumonia, instead of resolving, passes into a chronic condition. But there seem to be cases also in which a pneumonia is chronic from the outset. This is the case commonly in old persons, and it may therefore be said that **senile pneumonia** is included under the present head. To a certain extent the same is true of pneumonia in drunkards and in debilitated persons, especially when it affects the apex of the lung. In addition to that we have a very important group in which chronic inflammation is set up by the inhalation of irritating solid particles, as among potters, stone-hewers, etc. (See further on.)

The chronic inflammation here, as in other organs, is chiefly characterized by a new-formation of connective tissue, so that **Induration** of the lung is the result. In this view of it the terms chronic interstitial pneumonia, cirrhosis, sclerosis, are sometimes used as being virtually of the same meaning as chronic pneumonia. But here it is necessary to distinguish very carefully. We shall see afterwards that there is a form of tuberculosis of the lung commonly called fibroid phthisis, in which a great new-formation of connective tissue occurs. It is of importance to note that while fibroid phthisis leads to great shrinking and contortion of the lung, there is little of this effect in most cases of chronic pneumonia, the conditions in this respect differing from those in interstitial inflammation of the liver and kidneys.

The naked-eye appearances presented by the lung in cases of acute pneumonia which have had a prolonged course and have become chronic are not unlike those of the lung in the stage of grey hepatization. The disease is generally confined to one lung, and may affect only a portion of it. The lung is bulky and dense, and feels solid to the touch. When cut into, the solid lung has usually a grey colour, although sometimes with a tint of red, but it has a smoother cut surface than that in hepatization, and the tissue is much tougher. To this condition the name **Iron-grey induration** may be aptly applied.

Under the microscope the walls of the alveoli are greatly thickened by fibrous tissue, which largely encroaches on the alveoli, the epithelium of which is preserved, and sometimes occupies their interior. When it is considered that the lung as a whole is not reduced in bulk, and that the alveoli are in great part empty, then the overgrowth of connective tissue will be understood to be very great. Along with the interstitial new-formation there is commonly thickening and adhesion of the pleura.

In some cases there is a very striking appearance as if the fibrinous plugs in the alveoli in acute pneumonia were being eaten into and replaced by connective tissue. There are obvious masses of connective tissue inside the alveoli, sometimes distinctly pedunculated. These have arisen in a manner similar to that in which a thrombus becomes organized, the new-formed tissue moulding itself on the fibrinous plug. This appearance establishes the fact that chronic pneumonia sometimes develops out of acute, a view which has been questioned.

In some cases the new-formed connective tissue takes on a cicatricial character and by its contraction destroys and contorts the proper lung tissue. Just as in the case of cirrhosis of the liver, there is here an atrophy of the normal structure and a tendency in the organ to shrink. This leads to dilatation of the bronchi on principles already enunciated, so that **Bronchiectasis** is a prominent feature in advanced cases of this kind. The bronchial secretion may stagnate in the dilated bronchi and decompose; the irritation of the decomposing juices sometimes causes ulceration, and ragged cavities may thus form, so that the condition may come to resemble phthisis pulmonalis.

Literature.—Lænnec, Traité d'auscult. méd., 1819; Rokitansky, Lehrb. d. path. Anat., iii., 1861; Stokes, Dis. of chest, 1837; Friedländer, Ueber Lungenentz., 1873; Jürgensen, in Ziemssen's Handb., 2nd ed., 1882, and Volkmann's Lectures

(Syd. Soc. transl.), 1876; Gairdner, Clin. Med., 1862; Sturges, Nat. hist. and relations of Pneum., 1876; Collective Invest. Record, vol. ii., 1884; Hirsch, Geograph. und histor. Path., 1886, iii., 125; Russell, Peculiar outbreak of feb. disease, 1888; Strain (Epidemic pneumonia), Glasg. Med. Jour., xxviii., 331; Leyden (Abscess and gangrene), Volkmann's Samml., Nos. cxiv. and cxv., 1877; Auld, Lancet, 1890 and 1891; Sturges and Coupland, Nat. hist. and relations of Pneum., 1890; Washbourn (Pathology of Pneumonia), Brit. Med. Jour., ii., 1902.

VII.—GANGRENE OF THE LUNGS.

In this condition necrosis of a definite piece of lung tissue occurs. Necrosis of the lung is of frequent occurrence without gangrene; the latter implies that putrid decomposition has taken place and that the necrosed tissue has formed a slough. The occurrence of putrescence will depend on the local conditions, and chiefly on the presence of the microbes of putrefaction in the dead piece of lung. As such microbes are mostly present in the bronchi, putrescence will occur unless, as in tuberculosis, the preceding lesion fill up and obliterate the bronchi, or the conditions be otherwise such as to interfere with the microbes. The gangrene may itself arise by the action of decomposing material. If a foreign substance, such as a piece of solid food, gets into a bronchus it may induce a bronchitis with putrescence of the secretion, and the irritation of the putrid juices may induce gangrene of the lung. Similarly, putrid juices inspired from ulcers and wounds of the mouth and air-passages, or perforation of abscesses or ulcers into the trachea or bronchi may set it up. Again, the juices in cavities, especially in those arising by dilatation of bronchi, may stagnate and decompose, and lead to gangrene. Wounds and contusions may cause necrosis directly, and sometimes the lung tissue dies in severe cases of typhoid fever or other zymotic diseases. We have also seen that gangrene may occasionally follow hæmorrhagic infarction or acute pneumonia, and that it is a constant feature of metastatic abscess. Lastly, there are some cases in which the cause of the gangrene is obscure, but these cases, as well as those with a more definite cause, are somewhat common in debilitated persons and those given to alcoholic excess.

It is customary to divide gangrene of the lung into a circumscribed and a diffuse form. In both the lung tissue dies and decomposes, ultimately, if the patient survive, becoming separated as a shreddy slough, which occupies the cavity formed by the loss of tissue. In the diffuse form there are gangrenous patches throughout the lung, or a considerable portion of it, and there is little probability of e effects becoming limited by reactive inflammation in the neigh- urhood. The diffuse form not infrequently develops from the rcumscribed, the decomposing juices from the slough causing still rther necrosis.

The various changes which occur around a gangrenous piece of lung, d in more distant parts of the organ, are related to the irritating aracter of the slough. These changes are mainly inflammatory. he lung tissue in the immediate neighbourhood is acutely inflamed and ere is thus a zone of condensation around having the usual features acute pneumonia, often with a specially hæmorrhagic character. In is inflammatory zone the gangrene may advance. On the other nd the slough may be detached by the inflammatory process. In me, a more chronic inflammation occurs, and the slough is separated om the lung tissue by a layer of granulation tissue which produces pus undantly into the interior of the cavity. At the same time there may cur in a considerable tract of lung around the granulation tissue a ronic inflammation causing thickening of the alveolar wall and con- nsation of the lung similar to that of chronic pneumonia. If the ough be small enough, the cavity may, after the discharge of the ough, ultimately contract and form a cicatrix, but in the case of larger oughs a suppurating cavity may long remain.

The effect on the bronchi is of importance. The decomposing juices om the slough and from the inflamed lung tissue find their way into e bronchial tubes, where they set up an acute inflammation of a ghly suppurative character. A rich secretion of putrid pus is the sult. This secretion carried to the bronchi in other parts of the lung y set up a lobular pneumonia (*vide ante*), or there may be as a result ngrene in numerous small isolated patches. In this way multiple all abscesses may occur. If the gangrene be near the surface an ute pleurisy is the result, with fibrinous exudation. Sometimes the vity opens into the pleura, and we have a suppurative pleurisy, per- ps with pneumothorax (see Fig. 531).

An occasional complication of gangrene is **Hæmorrhage**. As the ough separates, the more resistant tissues retain their connection ngest, and the bronchi and larger vessels are sometimes seen as rigid abeculæ in the midst of the soft slough. The arteries resist disinteg- tion longest, but they are usually filled with thrombi and obliterated. ccasionally, however, the gangrene advances around an artery which still pervious, and in that case hæmorrhage of a serious or even fatal aracter may result.

Sometimes the gangrene leads to a definite septicæmia, or metastatic flammations result, having their seat especially in the brain. In this case the decomposing material gets into the pulmonary veins, having first caused thrombosis of them.

A peculiar feature of gangrene of the lung is the very abundant and highly **Putrid sputum.** The decomposing juices from the slough set up, wherever they are carried, acute suppurative inflammations, and the abundant inflammatory products also undergo decomposition. The bronchial tubes being weakened by the severe inflammation often undergo dilatation (bronchiectasis), and the material stagnates in them all the more, and decomposes. So it happens that in the cavity itself and in the dilated bronchi there are usually large quantities of putrid secretion. This is expectorated at intervals, and sometimes so abundantly that it pours out of the nose and mouth. The sputum is extraordinarily fœtid, and, if allowed to stand, deposits triple phosphates, crystals of margarine, etc. It also contains abundant pus corpuscles, many of them broken down by decomposition, pieces of lung tissue, and bacteria isolated and in colonies. Sometimes the sputum contains also spirilla.

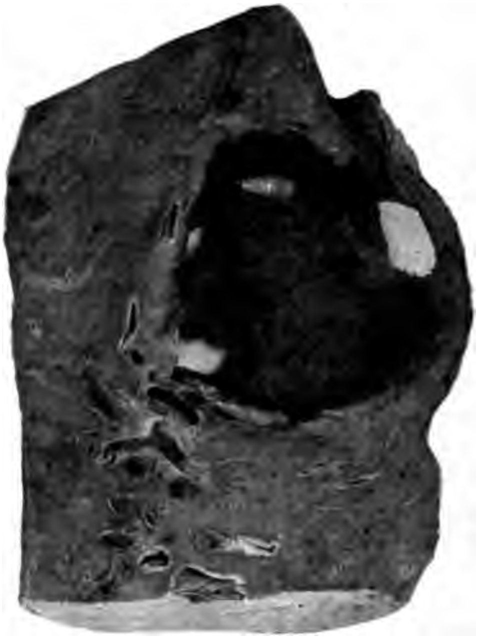

Fig. 531.—Large gangrenous cavity in the lung with pneumothorax.

Literature.—Lænnec, Traité d'auscult.; Leyden, Volkmann's Sammlung, No. 26, 1871; Hertz, in Ziemssen's Handb., v., 514, 1877; Hanot, Progrès méd., 1876, No. 14.

VIII.—PHTHISIS PULMONALIS. PULMONARY TUBERCULOSIS.

1. **Definition.**—The term phthisis pulmonalis was originally used to designate a wasting of the body associated with disease of the lung.

n its modern use it is applied to cases in which the lungs are affected y a progressive lesion, the ordinary and regular result of which is estruction of the lung tissue and the formation of cavities. The idea f wasting is thus transferred to the lungs, and associated with the natomical character of the lesion. It has always been recognized that uberculosis plays a considerable part in the pathology of phthisis pulonalis, but it is only of comparatively late years that a more complete emonstration has been furnished of the fact that virtually all cases conorming to the above definition are really cases of tuberculosis of the ung. There may be a few cases of actinomycosis, and possibly some f syphilis, in which lesions somewhat similar in character are produced, ut they are so few that phthisis pulmonalis may now be regarded as ynonymous with local tuberculosis of the lung.

It may be well here to refer briefly to the various phases through which the **views s to the pathology of phthisis** have gone since the time of Lænnec, especially as any of the terms in common use in connection with the disease are related to me of these views.

Lænnec believed that there was a particular tubercular matter which was liable be deposited in the lungs or elsewhere. It might be deposited in isolated places, rming miliary tubercles, or infiltrated into a considerable portion of lung, forming filtrated tubercle. In both cases the deposit usually began as a **Grey transparent** ructure, which, however, was prone to change into a yellow or whitish material at was drier and harder. This yellow material was called **Yellow or Crude tubercle**, hether occurring in the isolated or in the infiltrated form. All cases were regarded tubercular in which there were either isolated nodules or extensive infiltrations, hether these were grey or yellow.

By and by it came to be seen, however, that many of the conditions in phthisis re simply inflammatory. The minute histological characters of what we now ll the tubercle were discriminated, and the essentially inflammatory processes ere sought to be separated from the tubercular. It was shown that the existence f caseous material is no evidence of tuberculosis, since the ordinary products of flammation and other new-formations, such as tumours, may undergo this change, hich, in its essence, is really a necrosis with degeneration of the structures conerned. In phthisis, then, the process is largely an inflammatory one, with the pecial tendency in the products of inflammation to undergo a caseous metaorphosis. In this way arose Virchow's designation **Caseous pneumonia**—an nflammation with a caseous tendency in its products, just as scrofulous disease f the glands is an adenitis with a similar tendency.

When the lungs in phthisis were more particularly examined, however, it was ound that the condition was not such a purely inflammatory one as Virchow upposed. In all stages of the disease **Tubercles** are to be found alongside the nflammatory products. The tubercles undergo changes similar to the latter, nd it is often difficult to discriminate between the two, especially when aseous metamorphosis has occurred. But, in nearly all cases where the disease s advancing, proper tubercles are to be found along with the inflammatory onditions.

The more modern position brings us back more nearly to that of Lænnec. Again we regard phthisis as a tubercular disease, but not merely in the general sense of Lænnec. Our position differs also from Lænnec in this respect, that he regarded a particular state of the constitution as the essential cause of the tuberculosis. It is not to be denied that the lungs must be in a state of susceptibility before they can be affected by the tubercular virus, but the same may be said concerning any form of tuberculosis, and indeed concerning ordinary inflammatory processes. We know that different persons, or the same person at different times, are very variously susceptible to catarrhs, and to inflammations of all sorts.

We therefore regard phthisis pulmonalis as a **Local tuberculosis** in which inflammatory processes and the actual formation of tubercles manifest themselves, and both lead on to necrosis and ulceration.

2. **Causation.**—In what has been said above it has been implied that the causation of phthisis pulmonalis is connected with the tubercle bacillus. All that has been said in regard to the causation of tuberculosis at pages 187-189 applies here.

There is, in this as in other forms of tuberculosis, not only the action of the specific microbe to be considered, but also the susceptibility of the individual, which may be inherited, but is often acquired. It is acquired principally in the case of persons so placed as to have the general health reduced, and in whom especially the respiratory functions do not get justice. Persons living in close dwellings, especially when, at their work in factories and otherwise, they are in the habit of breathing vitiated air, in which, it may be, finely divided dust is abundantly suspended, frequently acquire a tendency to phthisis although not originally predisposed.

In relation to the resulting lesions, the **Path of entrance** of the irritant to the lungs is a matter of importance. In the study of the lesions met with we shall find that they all start at the finer bronchi. A catarrh of the finest bronchial tubes, usually occurring in a number of these simultaneously, is the starting point of a variety of lesions, which, however, for a considerable time remain related to the bronchi in their distribution. This is an indication that the agent finds access to the lungs by the inspired air.

As a general rule the bacilli probably find entrance in small numbers and by accident, but there are cases of a more considerable **Insufflation** of tubercular matter. Thus in a case observed by the author, a tubercular lymphatic gland adherent to a bronchus burst into the bronchus with the result of an acute tuberculosis in a limited district of the lung. There may also be a somewhat rapid extension from insufflation in tuberculosis of the larynx.

The **Localization at the apex of the lungs** of the earliest lesions is probably related to the fact that the apices of the lungs are the least xpansile portions. The first rib even in women is very little raised n inspiration, and in persons with weak respiratory movements the air s apt to stagnate at the apex. This view receives some confirmation rom the fact that phthisis so frequently improves when the patients o to reside in high altitudes where the rarefied air requires more igorous respiratory efforts. In such persons the size of the chest s a whole generally undergoes an increase. Remembering that the ubercle bacillus is of slow growth, we may presume that it is more ikely to obtain a footing when it is left undisturbed in parts where he air is more or less stagnant.

3. **Anatomical changes in phthisis.**—In studying the changes in the ung it will be necessary to give descriptions of the various processes eparately (and to a certain extent these processes are separable), ut at the same time it must be understood that many of them go on ogether and by their simultaneous occurrence frequently mask each ther. It may be said in general that the disease, beginning in the iner bronchi, tends to spread in one of two directions, or in both of hem at once, namely, along the bronchi to the lung alveoli, or else rom the bronchi to the surrounding connective tissue and on into the eneral connective tissue of the lungs. In both cases we find tubercles eveloped in all stages of the process, and in both there is inflammation, ut of different kinds according to the structures involved. In the one ase there is chiefly catarrh of the lung alveoli, although the alveolar all and surrounding connective tissue also show new-formation. In he other case the inflammation produces new-formation of connective issue and consequent induration. It is important to observe that the ubercles which occur in both cases partake, to a considerable extent, n the peculiarities of the inflammations. In the case of extension to he connective tissue the tubercles tend to undergo fibrous transformaion. In the other case they are liable rather to caseous necrosis.

(*a*) **The Caseous form.**—When the lungs are examined in an ordinary ase of this kind after death they are found adherent to the chest wall, nd they are usually seen to be the seats of several cavities, chiefly in he upper lobes. The cavities are of various sizes and very irregular n outline (see Fig. 532). There are very often one or more large ones divided by partial septa, evidently formed by the coalescence of several smaller ones. If the disease be in active progress, as is mostly the case at the time of death, the internal surface of the cavities is rough and irregular as if from ulceration. The cavities may contain a curdy pus, or they may be comparatively empty, but their internal surface is usually coated more or less with a yellow curdy matter. If the cavities are at all smooth on the surface, or free from the appearance

eration, these are signs that the disease is to some extent
tion of retrogression (see Fig. 533). The tissue immed
id is usually condensed and pigmented.

is necessary to look away from the cavities in order to o
ations of the **Initial lesion**. One can nearly always distin

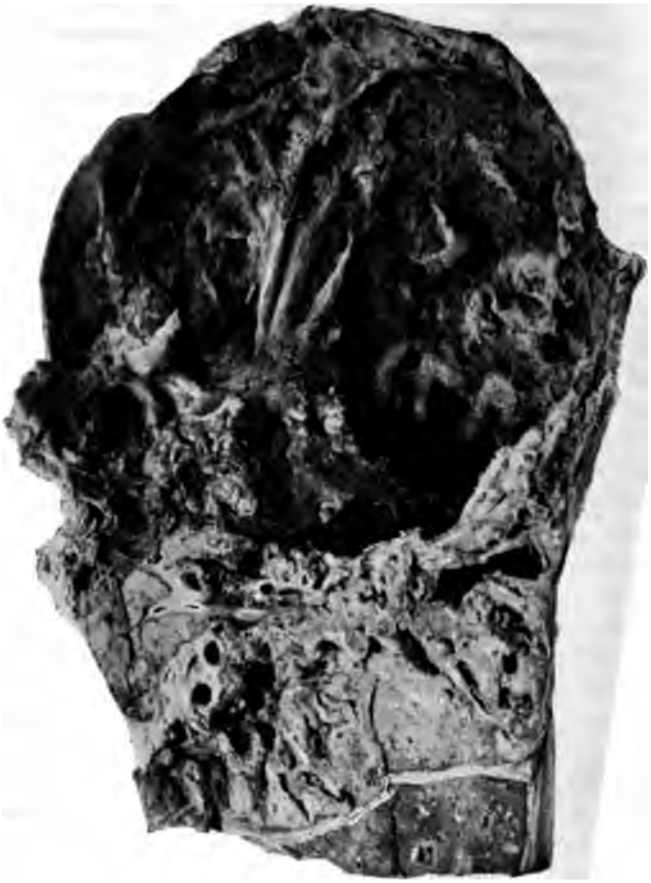

Fig. 532.—Caseous phthisis with large cavity in upper lobe.

in the midst of the crepitant and comparatively normal ti
areas of condensation, such as those illustrated in Fig. 53
be felt as solid masses in the soft tissue, and on section t
above the general level of the cut surface. They are us
less rounded in area and present on section indication
arrangement, there being a central stem and bodies gro
like grapes on a bunch. The central parts are gener

r and opaque, and this appearance may involve the whole area, he peripheral parts have usually a grey translucent character.

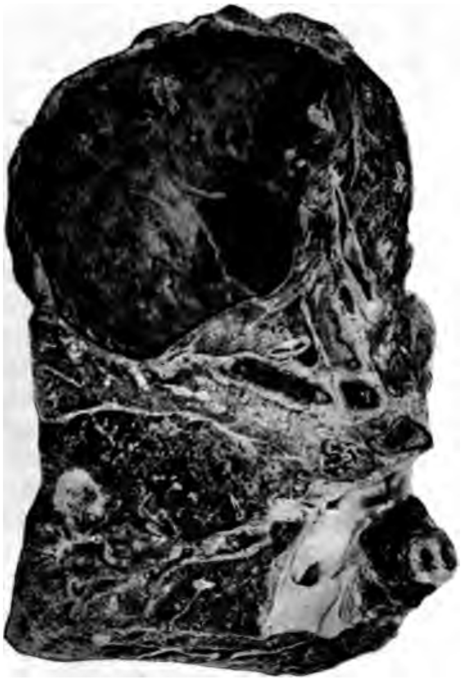

Fig. 533.—Large phthisical cavity with smooth walls.

oalescence of areas having these characters gives rise to con- ble condensations, in which no such lobular arrangement may

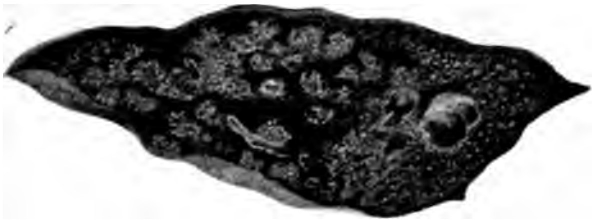

Fig. 534.—Lobular condensations in caseous phthisis.

ible, although at the margins there are generally indications of it ig. 535).

microscopic examination of the more recent of the initial lesions, ances will be found which may be illustrated by Fig. 536.

The lesion begins and centres in a small bronchus. The bronchus is plugged with what is at first merely an inflammatory exudation (*b*) consisting of desquamated epithelium and round cells. The outline of the tube is preserved (*a*) but its wall is considerably infiltrated with round cells (*c*). The plugged bronchi form the central stems and branching twigs of the areas under consideration, but there is an extension to the lung alveoli, and here also we have the effects of inflammation. The inflammation is generally of the parenchymatous or catarrhal character, and the alveoli are occupied by large catarrhal cells which are the derivatives of the alveolar epithelium. Sometimes the epithelium itself is seen enlarged and it may be desquamating. Blood is very often present along with the catarrhal cells, sometimes in such abundance as to fill the alveoli. In the specimen of which Fig. 536 is a drawing, for example, the alveoli contained much blood (see further on under Hæmorrhage).

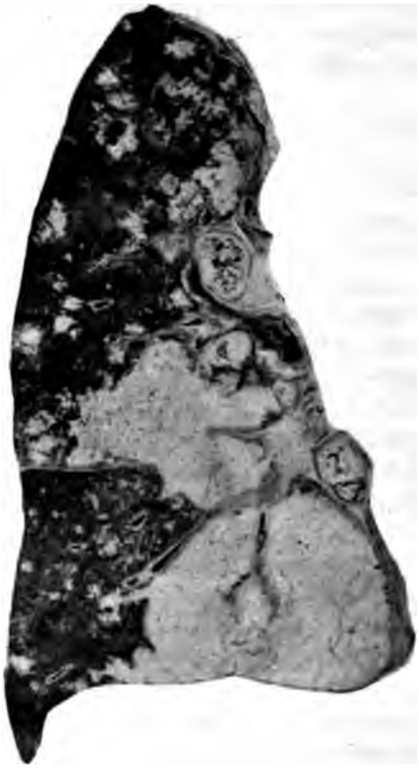

Fig. 535.—Caseous phthisis showing extensive areas of caseation.

The exudation in the alveoli is sometimes more like that of an acute nflammation, consisting to some extent of round cells, and there are ases in which even fibrine is present.

Besides these inflammatory conditions we have **Tubercles** present in he affected parts. The bronchial wall, as we have seen, is infiltrated ith leucocytes which, as they accumulate, obscure the structure of the all. They also extend to the connective tissue outside the bronchial all, and to the alveolar wall. In the midst of these evidences of nflammation definite tubercles are visible, sometimes typical in every espect (see Fig. 537). But they are apt to be somewhat indefinite om the existence of the inflammatory infiltration, so that only the iant-cells may be definitely distinguishable. The giant-cells not inequently take into their substance the black pigment of the lung ssue, and so may be somewhat strikingly manifest.

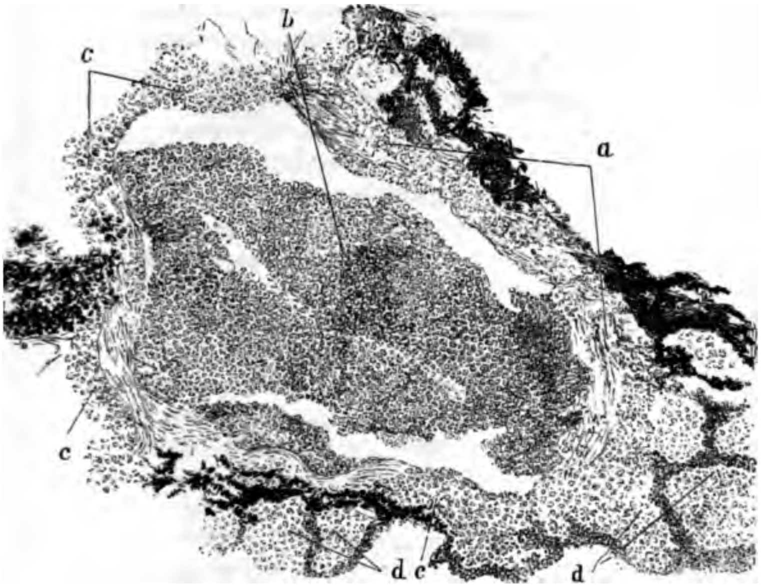

Fig. 536.—Caseous phthisis; recent centre. *a*, wall of bronchus with pigment externally; *b*, plug in bronchus; *c*, round cells infiltrating wall of bronchus; *d*, alveoli filled with blood and catarrhal cells. × 60.

Another feature which distinguishes the process is the occurrence of **aseous necrosis.** This consists, as we have seen, in the death of the ructures, accompanied by the production of finely granular fat. As is change reduces everything which it affects to a homogeneous anular condition, it greatly obscures the structure and renders the entification of the individual elements very difficult. It occurs in all the structures already described as affected by the inflammation, the plug which fills the bronchus, the bronchial wall, the contents of the alveolus, the alveolar wall, and the tubercles. If the process is not very advanced, then it may be seen that the caseous necrosis begins in the bronchus, as in Fig. 538, the outline of the tube being still visible. In this illustration the change has extended to the alveoli immediately around the bronchus, and their outlines are still obscurely visible in the midst of the general granular appearance. Outside the caseous area the alveoli are filled with catarrhal cells and their walls infiltrated with round cells. The caseous matter is visible to the naked eye as a yellow or white opaque substance which is somewhat brittle, and, like cheese, consists of nitrogenous matter containing finely divided fat.

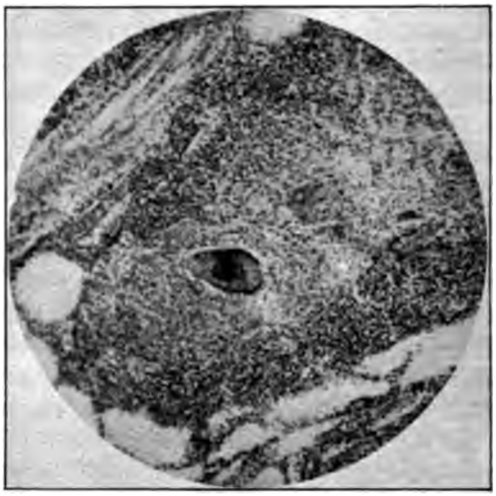

Fig. 537.—Tubercle with giant-cells in the lung in a case of caseous phthisis. × 100.

The dead caseous matter may lie for a long time and do little harm, just as any inert dead animal matter may. It may even undergo a partial absorption, or with this may be combined an infiltration with lime salts, so that ultimately a cretaceous mass remains embedded in the lung. These processes, however, imply that the tuberculosis has ceased to be active and that the caseous matter is inert. It is more usual to have a disintegration of the caseous matter.

Softening or breaking down of the caseous matter often shows itself to the naked eye in the central parts of the caseating areas. It can often be determined under the microscope that the softening is beginning in the situation of the bronchus, which thus again proclaims itself the ntre of the process. In Fig. 538 there are indications of a crumbling 'the caseous matter and a partial separation so as to leave cracks or ssures.

In this way **Cavities** are formed, and each cavity implies the death nd destruction of a certain portion of lung tissue, usually involving a ronchus and its surrounding alveoli The broken-down caseous material orms a grumous turbid fluid, in which the more resisting elastic tissue f the lung may be found still retaining to some extent the form of the lveoli. This elastic tissue may be frequently recognized in the sputum f such patients by proper methods of search (see Fig. 539). At first e cavity formed is small, but by extension of the process and alescence of neighbouring softenings, larger cavities result. These vities are very irregular, and their walls at first ragged and ill-efined. The cavity sooner or later opens into a bronchus, and s contents are discharged. When the caseous material is cleared t the wall assumes an inflammatory character and secretes pus ore or less abundantly. There may be ultimately a smoothing of e walls of the cavities by the formation of connective tissue, but ere is not the regular lining membrane of the bronchiectatic cavity,

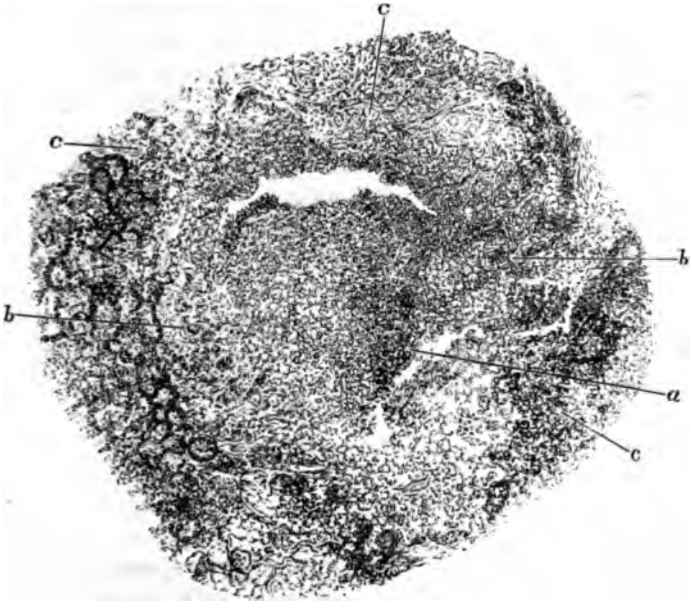

Fig. 538.—Caseous phthisis; further stage. *a*, caseous centre, including plug and bronchial wall, rendered indistinguishable by the caseation; *b*, alveoli scarcely distinguishable; *c*, alveoli further out, filled with exudation and having walls infiltrated. × 85.

nor the same relation to the bronchi. In the walls of such cavities, and in the mucous membrane of the bronchi with which they are in communication, tubercular ulcers may sometimes be distinguished.

It may be that, as Hamilton suggests, the softening of the caseous matter is by a process akin to that which occurs in the ripening of cheese, in which, according to Duclaux, certain insoluble albuminates become soluble in water.

According to Prudden, mixed infection may have something to do with the formation of cavities or with the acuteness of the disease. He found that in rabbits, whilst the insufflation of the tubercle bacillus produced tubercular lesions, yet cavities did not result, but the subsequent insufflation of the streptococcus pyogenes produced cavities. Prudden does not carry the whole of this by inference to the human subject, but suggests the influence of mixed infection, and especially of septic contamination consecutive to tubercular infection.

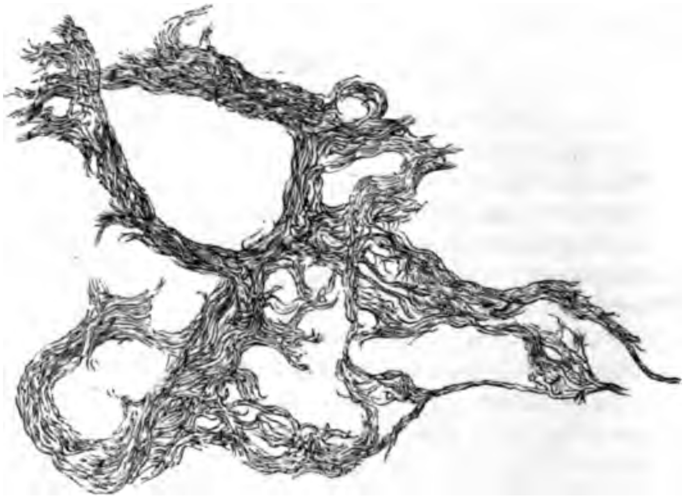

Fig. 539.—Lung tissue from the sputum in phthisis. The sputum was digested in caustic soda according to Fenwick's method, and then subjected to microscopic examination. × 350.

The whole process is sometimes a more acute one than that indicated above. The original exudation may approach in its characters to pus, and the process of softening may present little beyond a rapid necrosis akin to ordinary necrosis or sloughing. In these cases there is sometimes a **Purulent peribronchitis.** Suppuration occurs in the bronchial wall and in the surrounding tissue, and, these structures being broken up, the cavity partakes of the nature of an acute abscess. Some of these abscesses may be near the surface, and by rapidly undermining the pleura cause it to slough. By the separation of the sloughs the cavity of the abscess may come to communicate with the pleural cavity and so pneumothorax may result. Sometimes there is even a gangrenous condition developed, and actual sloughing of pieces of lung tissue occurs.

Acute cases such as these bespeak a peculiar virulence of the morbid agent or a peculiar susceptibility of the patient. They usually pass rapidly on to a fatal issue with high fever. In some cases recovery takes place, the pus dries-in or is discharged, and the abscesses become surrounded by indurated connective tissue.

(*b*) **The Fibroid form.**—On post-mortem examination in typical cases of this form the lung is found very firmly adherent over the affected part, which nearly always includes the apex. One often has to remove with difficulty a dense leathery cap which covers the apex of the lung (see Fig. 540). On cutting into the lung there are usually cavities, but they are not generally large and the internal surface is mostly clean and moderately smooth. A distinct membrane lines the cavity (*c* in figure). Outside the cavity the tissue is very dense and of a deep slaty colour in which opaque white spots may be occasionally visible. The densely pigmented tissue may involve a considerable portion of the lung and the affected part is shrunken and contracted (see figure).

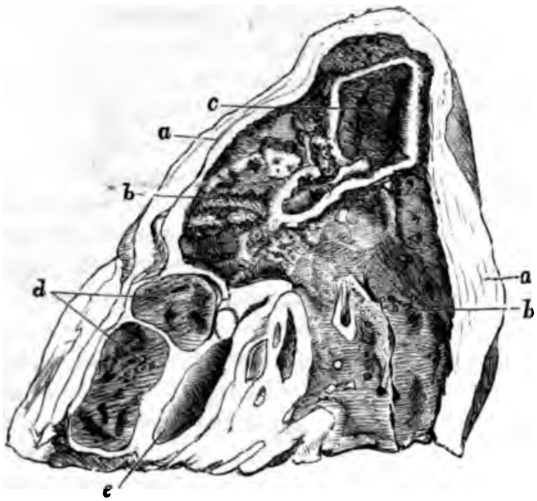

Fig. 540.—Diagrammatic sketch of the upper lobe of a lung in fibroid phthisis. *a*, *a*, greatly thickened pleura; *b*, condensed and pigmented tissue; *c*, cavity with distinct lining; *d*, bronchial glands enlarged and pigmented; *e*, main bronchus. The nearness of the bronchus and glands to the apex indicates the shrinking. Nearly natural size.

Looking away from the condensed part in which the lesion is advanced, we find, as in the caseous form, the advanced posts of the disease in the form of isolated condensations in the midst of the crepitating normal tissue. Here the **Initial lesion** is different from that in the other form. It consists in hard dark or nearly black solid bodies, scattered through the lung tissue. On running the finger over the cut surface one feels these bodies and they stand out above the general surface.

In this form as in the other a plugged bronchus will be found to form the centre of the initial lesion. This is shown in Fig. 541, which is from the centre of such a lesion. The bronchus contains, as before, inflammatory products, namely, round cells and desquamated epithelium. The wall of the bronchus is also infiltrated with round cells, and tubercles are present in the wall and in the surrounding connective tissue. There is, however, very little appearance of inflammation in the lung alveoli, and the affection seems to advance rather by the lymphatics into the connective tissue than along the mucous surface to the alveoli.

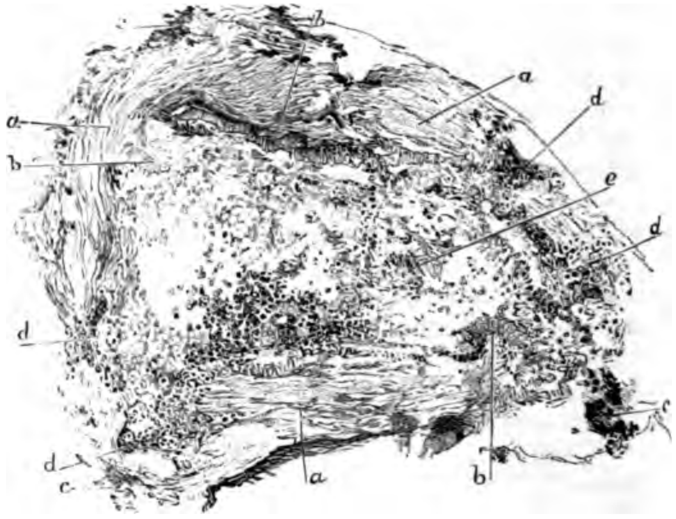

Fig. 541.—Fibroid phthisis, early lesion. *a*, *a*, bronchial wall; *b*, *b*, projecting parts still covered with epithelium; *d*, *d*, round cells infiltrating bronchus; *e*, exudation in calibre. × 60.

The distribution of the **Tubercles** is indicative of the advance in the directions just mentioned. They are often grouped in the neighbourhood of bronchi, as in Fig. 542, but are also present at some distance (*a* to left in figure), the process travelling by the lymphatics. The tubercles present in the earlier periods the typical structure, and there are frequently giant-cells in their midst.

Hæmorrhage is very common in this as in the other form. The blood in some cases fills out the alveoli.

Caseous necrosis is much less a feature in Fibroid phthisis than in the other form, but it is usually present in the plug which fills the bronchus, as well as to some extent in the bronchial wall. This is shown in Fig. 543, in which the central part (*a*) representing the plug is homogeneously granular, while the walls of the tube are infiltrated with round cells. In some places (as at *c*) there is a cellular aggregation which with a higher power is seen to be a tubercle.

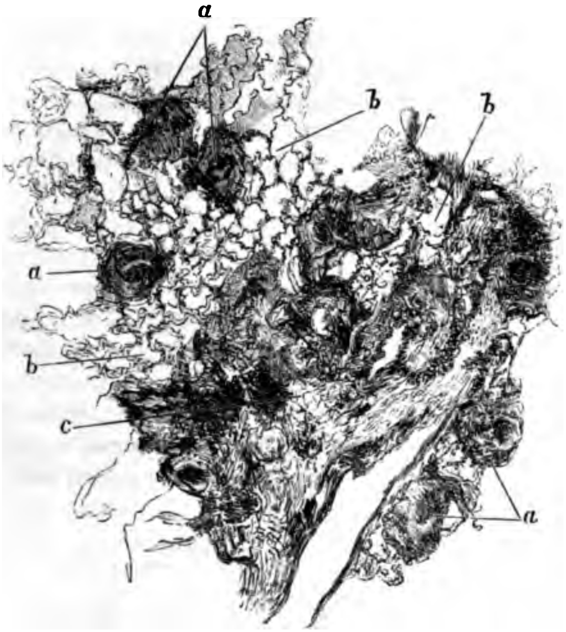

Fig. 542.—Fibroid phthisis. *a*, *a*, tubercles in connective tissue, some close to a bronchus, others removed; the darker centres indicate caseation, *c*; *b*, *b*, emphysematous lung tissue. × 20.

A feature present in this form, but not in the other, is **Fibroid transformation**, which affects both tubercles and connective tissue and gives its peculiar characters to this form of phthisis. The tubercles are converted into clear structureless bodies in which all the elements of the tissues are lost except, occasionally, one or two giant-cells. These may be partly transformed, but may still be recognizable, especially as they frequently contain a considerable number of black granules.

A similar fibroid transformation affects the connective tissue around the bronchus and extends to the general stroma of the lung. There is thus great induration of the lung tissue and the fibrous tissue shrinks and produces great deformity. The shrinking of the tissue, associated as it is with adhesion of the pleura, frequently leads to drawing-in of the chest wall,—often a characteristic feature,—and it leads also to two lesions which are often very apparent in the lung, namely, bronchiectasis and emphysema, both of which are complementary.

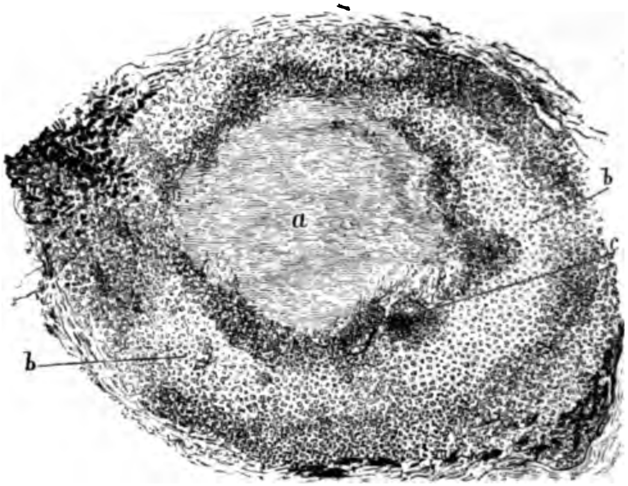

Fig. 543. Fibroid phthisis. *a*, bronchus plugged and caseous; *b*, *b*, wall of bronchus infiltrated with round cells and tubercles; *c*, tubercle in wall.

Bronchiectasis is, in this form, the most active factor in the formation of cavities. It is partly a purely complementary process, the shrinking being compensated by the dilatation of the air-passages. Hamilton and others have pointed out another mode of formation. As the chest wall forms a comparatively fixed point to which the shrinking tissue is attached by the pleural adhesions, and as this tissue is also attached to the walls of the bronchi, the result of the shrinking will be that these two points will be approximated, the chest wall drawn in and the bronchial wall drawn out. There is a third way in which bronchiectasis occurs. The secretions may accumulate in a bronchus behind an occlusion of the tube. Such an occlusion will occur when the primary lesion has affected a bronchus of larger calibre than usual, or where the shrinking tissue has constricted a bronchus.

The **Bronchiectatic cavity** is lined with a distinct membrane, and is usually directly continuous with a bronchus (see Fig. 540). It may exist as a complementary dilatation in the midst of crepitating lung tissue in a part not affected by the tuberculosis.

Emphysema is a frequent accompaniment of the process. Wherever iece of lung escapes the fibroid change, it is liable to emphysema on ount of the shrinking in its neighbourhood. Hence in the midst of shrunken tissue one often sees islands of lung tissue having a honeynbed appearance (see Figs. 542, *b*, and 544, *b*).

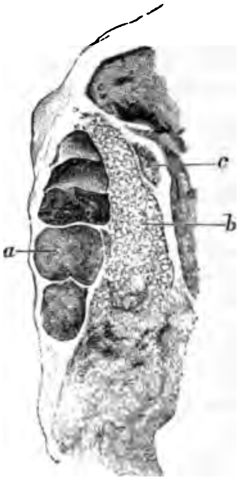

Fig. 544.—Fibroid phthisis. *a*, cysts in pleura from shrinking of lung; *b*, emphysema; *c*, cyst in interlobular connective tissue. Natural size.

Another occasional result of the shrinking is a formation of **Cyst-like ities** in the pleura, as shown in Fig. 544, *a*. e shrinking of the lung, dragging the adher- pleura with it, may cause spaces to form the pleura, or even in the interlobular septa at *c*), these spaces being filled with serous d.

igmentation is a peculiarly prominent ture in fibroid phthisis. Even the initial on is characterized by the almost black our of the nodules, and the indurated ue has a slaty or blackish colour (*slaty uration*). Perhaps the explanation of this hat the carbonaceous pigment (see further is retained by the affected bronchi and swept outwards by the cilia of the epilium.

The caseous and fibroid forms of phthisis in general distinguishable. They have tain points in common, chiefly in respect t each begins with a bronchitis of the finer es, and that each is characterized by the presence of tubercles. the one form, however, the bronchial inflammation extends to proper parenchyma of the lung, constituting a **Lobular bronchoumonia**, whereas in the other it is more localized around the amed bronchus, constituting a tubercular **Bronchitis and Perinchitis**. There is the further distinction that in the one form eous necrosis is characteristic, whereas in the other, while probably sent in most cases, it is limited in extent and may be confined to contents of the bronchi and the bronchial wall.

The difference is probably due to differences in the individual proities of the persons affected. In the fibroid form the disease is more onic, the persons affected are as a general rule older, and it occurs re frequently in the male sex. All these facts point to the conclusion t in this form there is greater resistance on the part of the tissues the morbid poison. This is confirmed by the resemblance which the cess, in some respects, presents to that which is concerned in the healing of phthisis. It may be said that in the caseous form the tissues are directly killed by the progress of the disease, sometimes with great rapidity, whereas in the fibroid form there is a long struggle and very little palpable softening or destruction.

This being the case it may be inferred that the two forms are not absolutely distinguishable. They run into each other, and the caseous form may assume many of the characters of the fibroid, especially when it becomes very chronic or partial recovery takes place.

The **Sputum** in phthisis pulmonalis is variously composed. In the earlier stages the expectoration has the usual characters of that in catarrh, consisting of mucus, with more or less abundant leucocytes. In the sputum in this early stage large epithelioid cells with one or more nuclei, such as we find in the lung alveoli in the catarrhal form of phthisis, are often found. These cells frequently present fatty degeneration. The sputum in phthisis often contains **Elastic tissue** from the breaking down of the lung. In very rapid cases we may find this by a simple examination of the sputum, but the search is often a difficult one, because the thick mucus and pus hold the pieces of lung tissue suspended and isolated. By Fenwick's method of digestion in soda solution, pieces of lung tissue, such as that shown in Fig. 539, will frequently be found in the deposit. This method is also applicable to the sputum in gangrene of the lungs. The **Tubercle bacillus** is usually to be found in the sputum, and is of great diagnostic value. The appearances are shown in Fig. 62, p. 187.

4. **Extension of the tuberculosis in phthisis pulmonalis.**—In both of the forms already described it has been shown that the tuberculosis, beginning in the finer bronchi, extends, on the one hand, to the lung alveoli, and, on the other, to the connective tissue. Besides that, however, there are further extensions both in the lung and beyond it.

An existing cavity, especially one arising from disintegration of caseous matter, is a great source of infection, its contents being charged with tubercle bacilli. The infected matter is carried from the cavities and is partly insufflated into other parts of the lungs and partly discharged. It thus causes an extension of the disease in the lung itself, and is liable to infect the air passages as it is carried along.

Hence, **Tuberculosis of the bronchi** is very frequent in connection with cavities, the mucous membrane becoming the seat of tubercular ulcers. If the bronchial tubes be opened up, the ulcers are visible as more or less rounded erosions, sometimes with distinct white tubercles at their borders.

A further extension to the **Larynx and Trachea** is very common, and from these, by way of the œsophagus and stomach to the **Intestine**.

There is also an extension by the lymphatics, so that in nearly all cases of phthisis the **Bronchial lymphatic glands** are affected. The condition here is similar in character to that in the lungs. In the aseous form the glands are caseous, resembling closely the appearances n ordinary scrofulous glands. In the fibroid form they are liable to e more or less fibrous and deeply pigmented. Tubercles are present n the glands, sometimes in the most typical form. It is not common or softening to occur in the bronchial glands; the tuberculosis is sually chronic in character and the affected glands may ultimately hrink and become calcified. Cretaceous matter is often met with at he roots of the lungs,—the remains of obsolete tuberculous glands.

5. **Healing of phthisis.**—In this connection it is to be remembered hat tuberculosis is due to an infective material, which usually goes on eproducing itself. In the healing of tubercular lesions generally there re two methods which may be followed, and in phthisis pulmonalis e have examples of each of these. On the one hand, the infective atter may be cleared out and the parts around become the seat of imple inflammatory processes, or, on the other hand, the caseous atter may have its infective character overcome and be left as a piece f innocuous dead matter in the tissues. In either case, so far as the ng is concerned, there is implied an increase in the vigour of the arts, so that the infective character of the matter may be annulled.

When cavities have formed by the softening of the caseous matter, he disease may pause. In that case the wall of the cavity comes to be omposed of healthy granulation tissue, which develops into connective issue as in the ordinary cicatrix. If the cavity is so situated that conraction can occur, then there may be a shrinking till it is completely bliterated, and a **Cicatrix** takes its place. On the other hand, circumtances may allow of only partial contraction, and the cavity remains, ut its wall comes to be formed of connective tissue without any trace f recent tuberculosis (see Fig. 545).

In other cases the caseous matter fails to soften, the disease is hecked before cavities are formed, and in that case we have necrosed tructures lying in the lung. In this case granulation tissue is formed round the dead matter, and may partly eat into it. By development nto connective tissue a capsule is formed around the dead matter, and he latter by and by becomes impregnated with lime salts, so that ltimately particles of lime or considerable **pieces of cretaceous matter** re present in the midst of a cicatrix.

It is worthy of note that the connective tissue formed in both these orms of healing is deeply pigmented, so that in this respect the proesses are comparable to those concerned in fibroid phthisis.

Healing by one or other of these processes is of frequent occurrence. In the ourse of post-mortem examinations one very frequently meets with pigmented icatrices, often with chalky particles in their midst, at the apices of the lungs, the pleura being adherent over the affected parts (see Fig. 68, p. 196). In some cases healing may take place after such extensive destruction of the lung with formation of cavities as that shown in Fig. 545. Here almost the whole lung is converted into a congeries of cavities, the walls of which are smooth and show no recent action. There had been an acute tuberculosis of the lung years before. If, after healing, a return of the disease takes place, the chalky matter may afterwards be separated, and such pieces are sometimes expectorated (see Fig. 546).

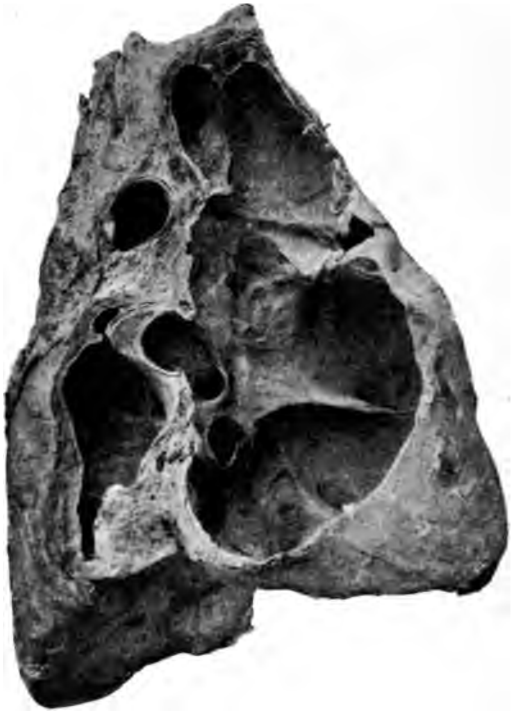

Fig. 545.—Healed cavities in lung. The figure is from a photograph of the entire lung displayed by section. There is a congeries of cavities with smooth walls and no appearance of recent action.

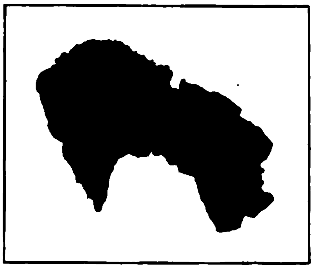

Fig. 546.—Cretaceous mass expectorated by phthisical patient. Actual size.

The frequency of healing of tuberculosis of the lungs has been estimated by the author, Harris, and others, on the ground of post-mortem observation in cases which have died from non-tuberculous disease. The result is that in about 20 per cent. of persons dying from other diseases there has been at some period of life a tuberculosis of the lungs which has become obsolete.

6. **Hæmorrhage in phthisis.**—Hæmoptysis is one of the most common manifestations in phthisis. It is necessary to distinguish between an early and a late hæmorrhage.

(*a*) **Early hæmorrhage.**—In examining the initial lesion in phthisis, whether in the caseous or fibroid form, it is common to meet with alveoli filled with blood, presenting an appearance very similar to that shown in Fig. 521, which is from a hæmorrhagic infarction of the lung. The blood may be so abundant and occupy so many alveoli, as to give quite the character, on a small scale, of hæmorrhagic infarction.

The blood here comes from the pulmonary capillaries, escaping by diapedesis; it does not arise by insufflation, else it would be more mixed with air and broken up. The homogeneous complete filling of the alveoli implies a regular leakage which gradually expels the air. The blood also is often in alveoli which are little altered otherwise, and it is present in a considerable group of alveoli together.

These facts would indicate a local interference with the circulation as a cause of the hæmorrhage. Such an interference is liable to occur from the proximity of the branches of the pulmonary artery to the bronchi. The arteries and bronchi run to a large extent parallel, their sheaths continuous, and the inflammatory changes in and around the bronchi which form such an important part of the initial lesion may well exercise pressure on the arteries. This view is confirmed by the fact that in general tuberculosis of the lung a similar hæmorrhage is very often present, sometimes to a very aggravated extent. In this affection the tuberculosis is usually so intimately related to the arteries, that there is a direct interference with them.

In any case the hæmorrhage is part of the initial lesion, and it is known that the appearance of blood in the sputum is often a very early sign of phthisis.

As the hæmorrhage is associated with the earliest lesions it may occur at a time when no symptoms of disease in the lungs are present, and may be the apparent starting-point, although not really so. The occurrence of hæmorrhage has been regarded as sometimes the origin of phthisis, a view which has been expressed by the term *Phthisis ab hæmoptoe*. This view is without adequate foundation, and the hæmoptysis is probably, in every case, evidence of the existence of the initial lesion. It is not improbable, however, that the occurrence of hæmorrhage may accelerate the progress of the disease, as the bacilli may possibly find in the blood a suitable nidus, and so exhibit a more rapid growth.

(*b*) **Late hæmorrhage.**—The hæmorrhage described above may occur at intervals throughout the course of the disease, but in advanced cases a much more considerable and not infrequently fatal hæmorrhage is liable to occur. In this case the bleeding arises by **Rupture of branches of the pulmonary artery** which have been partially exposed in the walls of cavities.

As a general rule the arteries in the walls of cavities are obliterated, more especially in the caseous form, but where obliteration has not completely occurred the wall of the artery being unsupported and perhaps softened by inflammatory infiltration is liable to give way. Before the actual rupture the vessel wall usually bulges out, so as to form an **Aneurysm** (see Fig. 547). In this figure the cavity is a bronchiectatic one, and its wall was comparatively unaltered, the aneurysm having arisen purely from want of support. In the caseous form there is softening of the wall of the artery, and the aneurysm has not such a definite sac as in this case.

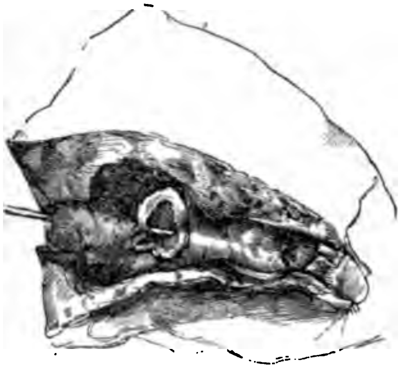

Fig. 547.—Aneurysm in a bronchiectatic cavity. A probe has been introduced into the artery, and is visible through the gaping aperture in the aneurysm. It is also indicated close to the wall of the bronchus beyond the cavity.

In cases of this kind the hæmorrhage is often very great, but even in the case of a considerable tear it may be stilled by the blood coagulating in the cavity and forming a kind of cap over the aperture.

7. **Affections of the pleura in phthisis.**—From the intimate connection of the pleura with the lung it may be expected that it will frequently be affected in phthisis.

The lymphatic system of the lung does not apparently communicate directly with the cavity of the pleura, so that although a tuberculosis may extend to the subpleural tissue it does not directly affect the pleural sac.

The relations of the pulmonary lymphatics to the pleura are shown by the locality of the carbonaceous pigment in the lungs. This carbonaceous pigment is carried about and deposited wherever there are communicating lymphatics, and it is often abundant in the subpleural tissue; but it never penetrates into the sac itself. On the other hand, there seems to be a communication in the opposite direction from the pleura to the interlobular connective tissue. This is shown by the fact that in tubercular pleurisy there is a certain penetration from the pleura into the lung. (See under Tubercular Pleurisy.)

While tuberculosis does not extend to the pleura, because it implies the passage of solid bodies (the bacilli), there are very commonly simple inflammatory processes, which depend on the extension of the dissolved products. Such products being present in the connective tissue of the lung may readily soak into the pleura.

Chronic pleurisy is a constant occurrence, giving rise, as in other cases of chronic inflammation, to new-formation of connective tissue. The pleura over a tubercular lung is nearly always thickened, sometimes greatly so (as in Fig. 540), and the two layers are almost constantly adherent. Not only are the two layers adherent, but they have eally coalesced, and their blood-vessels intercommunicate, so that if he vessels on either side be obstructed the pleura may be still nourished from the other. The thickening and adhesion are conservaive processes, shutting off the diseased lung from the general pleural ac. It is when these conditions fail to occur that we commonly have he more serious pleural lesions, acute pleurisy and pneumothorax.

Acute pleurisy is a frequent concurrent in cases of phthisis, especially n the caseous form. It implies that the lesion in the lung has come to the surface at a place where adhesion of the pleura has not yet taken place. It is most frequent in early periods and in acute cases.

The acute pleurisy is often connected with **Necrosis** of the pleura. The pulmonary pleura is nourished by the vessels of the lung, and as these are occluded and necrosed when involved in the caseating lesion, the pleura will be involved in the necrosis in so far as it is related to the occluded vessels. At the very outset of a caseous phthisis one of the affected areas may be immediately beneath the pleura, and we may have a necrosis before there has been time for the formation of adhesions. In this way may be explained many of the cases in which pleurisy has apparently but not really preceded the pulmonary disease. Again, in all acute cases we are liable to have necrosis of the pleura, and it is not uncommon to find quite a number of dead white areas visible on the surface, each indicating an area of necrosis, generally concealed to some extent by a layer of fibrine, the result of the nflammation.

The mere exposure of a necrosed piece of pleura seems to induce an acute pleurisy, perhaps by allowing the penetration of irritating juices uch as the living structures intercept. The acute pleurisy is of he usual kind (see further on) accompanied by fibrinous exudation, but it is usually limited by existing adhesions. Through time the acute inflammation subsides and a chronic pleurisy, with adhesion, results.

Pneumothorax also implies necrosis of the pleura, but there is, in addition, a partial separation of the dead piece and the establishment of a communication between the pleural sac and the air passages. This infers the existence of a cavity beneath the necrosed piece of pleura and not merely a caseous area. The necrosed piece begins to separate at one edge, and then the pneumothorax suddenly occurs. As death often results in consequence of a pneumothorax, one not infrequently has the opportunity of observing the condition in this stage. If the patient survive, then the whole piece is detached and apertures are left in the pleura.

Along with pneumothorax there is an acute pleurisy. If it has not occurred in consequence of the necrosis, then it will ensue when some of the contents of the pulmonary cavity pass into the pleural sac. These two conditions, acute pleurisy and pneumothorax, are thus closely related, both of them being connected with necrosis of the pleura. They also occur in relation with the advanced outposts of the pulmonary lesion, and are hence liable to develop in connection with the less affected lung or portion of lung, and by causing serious damage to the lung on which the patient chiefly depends for respiration, they often induce very serious and even fatal dyspnœa.

8. **General effects of phthisis.**—In its general influence on the body phthisis pulmonalis is of great importance.

Its most constant effects are **Emaciation and Anæmia**, the former of which, as we have seen, was the main element in suggesting the name phthisis. These conditions have their source chiefly in fever.

Fever is an almost constant accompaniment of phthisis, altogether apart from any general tuberculosis. It is to be referred to the presence in the blood of the various products evolved in the course of the local processes. These consist in part of the products of the specific microbe, which will pass into the blood, even when the microbes themselves do not. There will also be the products of the disintegration of blood, and of inflammatory exudations, such as those in pleurisy. In pulmonary cavities again, various forms of decomposition, putrid and other, are liable to occur, and the products naturally lead to fever.

Amyloid disease occurs in about a fourth of the cases of phthisis, and is more frequent proportionally in the fibroid than in the caseous form. It usually affects the spleen, kidneys, liver, intestine, and lymphatic glands, but there are great differences in its distribution and extent. It may be absent in any one of the situations mentioned while present in the others, or it may be greatly exaggerated in one while very inconsiderable in others. (See the author's "Lectures to Practitioners.") It is typically present in the spleen in the majority of cases, taking the form of the sago spleen.

Disease of the kidneys is a frequent concomitant of phthisis. It may be amyloid disease, complicated (as amyloid disease regularly is) with chronic nephritis, or it may be a tuberculosis. On the other hand there is not uncommonly a nephritis, sometimes in an acute or subacute form so as to produce enlargement with fatty epithelium, sometimes in a more chronic form, with contraction and granulation of the kidneys.

In cases of amyloid disease the mere presence of the amyloid material may induce chronic inflammation, but there is a considerable number of cases in which nephritis is present in an acute form. In these cases we may suppose that the products from the disintegrating processes going on in the lungs lead, by their discharge through the kidneys, to an inflammation of these organs (see author, loc. cit.).

General tuberculosis not infrequently follows phthisis pulmonalis. We have seen that the disease in the lungs is a local tuberculosis, and as a general rule it extends along mucous surfaces and lymphatic channels. In a considerable proportion of cases, however, the tubercle bacilli to some extent reach the blood and are carried throughout the body. If the liver be examined microscopically there will usually be found a few tubercles, generally in various stages of degeneration. There are also not infrequently a few tubercles in the kidneys visible to the naked eye. We sometimes meet even with a more considerable tuberculosis in the kidney and elsewhere, constituting a **Chronic general tuberculosis** (see p. 199), especially in children.

Acute general tuberculosis is a less frequent result and is generally due to a definite extension of the local tuberculosis to a branch of the pulmonary vein which has not become occluded by the advancing lesion (see p. 200). It may also arise by an extension of the tuberculosis from the bronchial glands to the thoracic duct.

Literature.—The literature of phthisis is very extensive. The older literature will be found in Waldenburg, Tuberculose, Lungenschwindsucht u. Scrofulose, 1869. See further, Carswell, Illustrations of path. anat., 1838; Virchow, Lehrb. d. spec. Path., i.; Niemeyer, Klin. Vortr., 1867; Buhl, Lungenentz. Tuberc. u. Schwindsucht, 1872; Rühle und Rindfleisch, Ziemssen's Handb., v.; Weigert, Virch. Arch., lxxvii., lxxxviii., civ.; Koch, Etiology of tuberculosis, Syd. Soc. transl., 1886; Baumgarten, Tuberkel und Tuberculose, 1885; Kidd, in Allbutt's System of Med., v., 1898; Weichselbaum (Inhalation), Wien. med. Wochenschr., 1883; Tappeiner, Virch. Arch., lxxiv. and lxxxii.; Zeigler, Volkmann's Samml. No. 151, and Lehrb.; Hamilton, Path. of bronchitis, etc., 1883; Ewart (Position of cavities), Gulstonian lectures, 1882, in Brit. Med. Jour.; Prudden (Formation of cavities, etc.), New York Med. Jour., 1894; Thompson, Family phthisis, 1884; Jaccoud, Curability of pulm. phthisis, 1885; Powell, Dis. of lungs and pleura, 1886; WILLIAMS, Pulmonary consumption, 1887; KIDD (Distrib. of bacilli in the lung), Med. Chir. Trans., lxviii., 1885; YEO (Contagiousness), Brit. Med. Jour., 1885, i.; COATS, Lect. to practitioners, 1888; GERMAIN SÉE, Bacillary phthisis; JAMES, Pulmonary phthisis, 1888; DOBELL, Bacillary consumption, 1889. *Healing of Phthisis*—HARRIS, Brit. Med. Jour., 1889, ii.; COATS, ibid. See also Literature of Tuberculosis, p. 201.

IX.—DISEASES FROM INHALATION OF DUST. PNEUMOCONIOSIS.

Carbonaceous pigment in the lungs.—The lungs of all adults have more or less of a grey colour from the existence of a black pigment in the lung tissue. This pigment is absent from the lungs of children, and is undoubtedly the dust inhaled with the inspired air. The air of all confined spaces, such as rooms, contains in suspension finely divided particles, particularly in cities where coal is burnt extensively, and this attains its maximum in the black fogs of such cities as London and Glasgow. The particles of dust inhaled with the air are for the most part caught by the mucus with which the surface of the bronchial tubes is moistened, and as the ciliated epithelium plays in the direction towards the larynx, the dust-laden mucus is carried upwards to the larynx, where it is either expectorated or swallowed. No doubt when the air is unusually laden with dust the mucous secretion is increased, and those who live in cities know that in foggy weather a considerable mass of black mucus is brought up from the larynx in the morning, the busy cilia having swept it thither during the hours of sleep.

But some of the dust penetrates beyond the reach of those scavengers and passes into the lung alveoli, where it lodges. From the lung alveoli it penetrates into the lung tissue. It is to be remembered that the structure of the alveolus is somewhat like that of a serous membrane. There is a single layer of epithelium, and stomata or pseudo-stomata have been described. The dust particles penetrate through or between the epithelial cells and emerge into the lymph spaces of the alveolar wall. Having entered the lymphatic system of the lung, the dust is carried into all the communicating channels of that system, and is partially deposited and retained as it goes by the connective-tissue cells. In this way a kind of pigmentation of the entire lymphatic system of the lung is obtained, which for demonstration may serve the purposes of an injection of that system. In this conveyance of the dust particles the leucocytes which are always present in the lymphatic spaces probably play an important part. The parts pigmented are, the walls of the alveoli, the interstitial connective tissue, especially that around the pulmonary artery and the bronchi, and the subpleural tissue, which is often definitely demarcated from the pleura proper by the pigmentation. The pigment is also carried to the bronchial glands at the root of the lungs, which are more or less blackened. This pigment is a carbonaceous material consisting mostly of round particles, and is to a great extent the soot of coal.

While the light dust of the air, reaching the lungs in small quantities, does comparatively little harm, damage may be done when large quantities of dust of a specially irritating character reach the lungs. Hence a distinct class of diseases has been distinguished as due to inhaled dust.

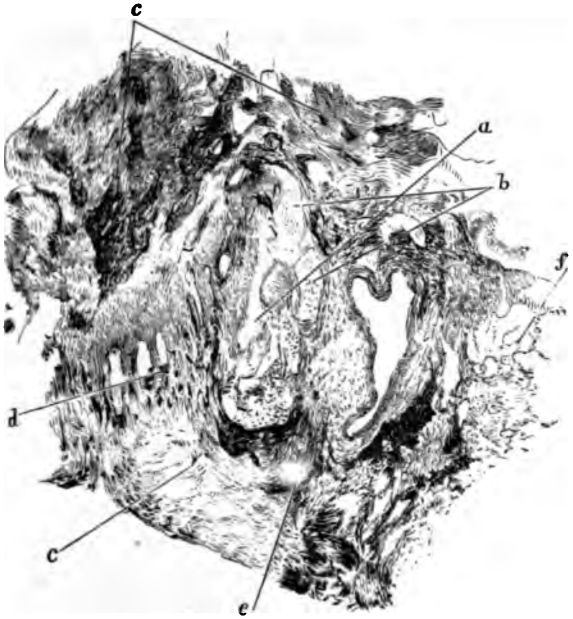

Fig. 548.—From a potter's lung. *a*, bronchus compressed and narrowed; *b*, two of its cartilages; *c*, *c*, condensed and pigmented lung tissue; *d*, lung alveoli, stretched and enlarged, some with pigment in them; *f*, lung alveoli emphysematous. × 8.

Diseases due to inhaled dust. Pneumoconiosis, Pneumonoconiosis.—This subject has been very fully worked out in this country by Greenhow, and in Germany by Zenker and Merkel. The results of the inhalation depend largely on the mechanical character of the dust. If it be heavy and composed of sharp angular particles, then it is more irritating than if it be light and composed of rounded pieces.

The particles entering the lung tissue in the manner mentioned above act as foreign bodies and set up a chronic inflammation. There is great new-formation of connective tissue, as in chronic interstitial pneumonia, and great shrinking of the tissue, so that considerable deformity of the lung may occur. As the irritant finds access by the air passages, the lesion in its earlier stages concentrates itself around the bronchi. This is shown in Fig. 548, in which it is seen also that the lung alveoli are subject to great contortion (at *d*), and that in the neighbourhood they are liable to emphysema (at *f*).

The dust, whatever its kind, may be visible in the midst of the lesion in the lung. It was the observation, by Zenker, of a red pigmentation of the lung in workers with the red oxide of iron, which furnished an absolute demonstration that the dust actually finds its way into the lung tissue. We may find in the lung, coal dust, the dust of potter's clay, soot from smoky lamps, stone dust, metal dust, and dust composed of cotton or woollen fibre. In Fig. 549 a collection of silicious particles from the lung of a worker in a pottery is shown.

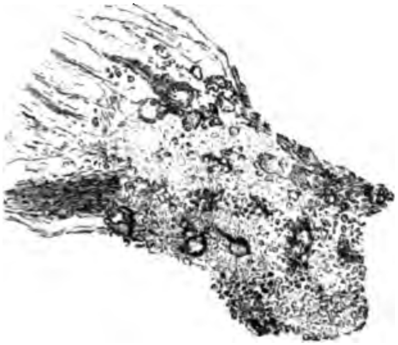

Fig. 549.—Silicious particles in a potter's lung. × 340.

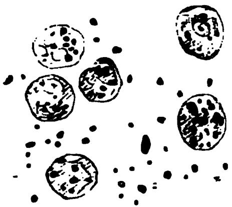

Fig. 550. - Part of the contents of a lung alveolus in anthracosis. Black particles are seen, some angular and others rounded. The large catarrhal cells contain many particles. × 350.

A peculiar feature in almost all cases of disease from inhalation of dust is the presence of an excess of **Black pigment** in the lung. In some cases the inhaled dust is black, so that a condition of anthracosis is brought about. But even when the dust is not black, as in the potter's lung, the affected districts of lung are deeply pigmented. The reason of this is not quite apparent.

Various names are given to the forms of lesion according to the kind of dust inhaled.

The **Coal-miner's lung** has an almost coal-black colour, and when incised it yields a black juice which stains the hand. The dust here is finely divided coal and the soot from the smoky lamps used in mines. The pigment is in the connective tissue, but it is often present also in the lung alveoli, where it may be taken into the substance of catarrhal cells (see Fig. 550). There is not usually much induration of the coal-miner's lung, as the dust is not physically very irritating. The term **Anthracosis** is given here owing to the extremely black appearance nted. An exceedingly well-marked example of this condition was tly observed in the lungs of a manufacturer of boot-blacking.

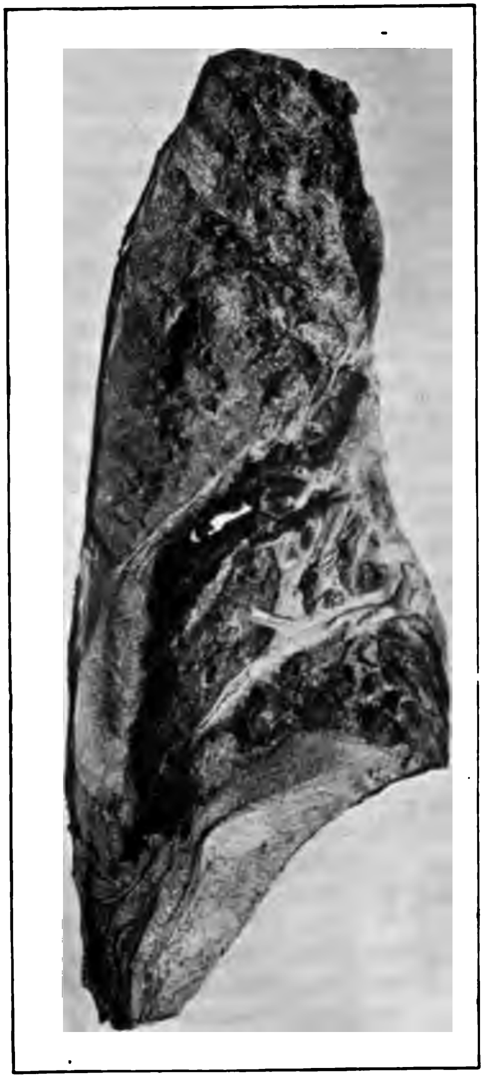

Fig. 551.—Section of a Sheffield needle-grinder's lung.

. miners are subject to catarrh, and the expectoration is usually stained so as n the **Black spit.** It is noteworthy that on a recurrence of catarrh, even years he patient has ceased working in the pits, the black spit may return. The nt stored up in the lung tissue returns to the alveoli and bronchi. This would indicate that a bronchial catarrh goes deeper than the mucous membrane. The agents in the return of the pigment are the leucocytes.

Potter's phthisis is a term used for a very frequent form of disease amongst potters. The dust here, consisting of heavy angular particles, seems very irritating, and excites much chronic inflammation.

Stone-mason's lung resembles the potter's form, as do also **Knife and Needle-grinder's disease** (see Fig. 551).

The connection of these forms of disease with phthisis is a point of some importance. A true tuberculosis may possibly be induced by the inhalation of irritating dust. There is, however, little evidence of that, and undoubtedly the great majority of cases of lung disease from inhalation of dust are quite different from cases of phthisis. There is no formation of tubercles, no caseation, seldom any formation of cavities, although these sometimes form by bronchiectasis. There is also the important clinical difference that persons affected with such diseases do not suffer in their general health as do tubercular patients. There is little or no fever, and the patients generally work on for many years till the dyspnœa incapacitates them (Greenhow, Coats).

Literature.—GREGORY and CHRISTISON, Edin. Med. Journ., xxxvi., 389, 1831; HAMILTON and GRAHAM, ibid., xliii., 297, 1834; THOMSON, Med. Chir. Trans., 1840, xx. and xxi.; ZENKER, Deutsch. Arch. f. klin. Med., ii., 1866, and xxii., 1878; ARLIDGE, On the diseases prevalent among potters, Social Science Cong., 1871; also ALLBUTT'S System of Medicine, v., 1898; GREENHOW, Path. Trans., 1866 to 1869; COATS, in Lect. to Pract., 1888, p. 150; Catalogue, Path. Museum, West. Infirmary. Glasgow.

X.—ACUTE MILIARY TUBERCULOSIS, SYPHILIS, ACTINOMYCOSIS, GLANDERS.

Acute miliary tuberculosis.—This condition has been discussed at page 200. The tubercular virus, being present abundantly in the blood, produces very marked lesions in the lungs. As the virus is brought by the blood, the lesions are generally homogeneously distributed throughout both lungs, and are intimately related to the finer branches of the pulmonary artery.

The lungs are found studded from apex to base with innumerable small bodies, generally whitish in colour. There is in addition a general hyperæmia of the lungs.

Under the microscope it can be seen in most cases that the tubercles are formed in connection with arteries. A small artery will generally be seen at the edge of or running directly into a tubercle, and it is not uncommon to find a tubercle in the wall of an artery, as in Fig. 71, p. 200. The tubercle has the usual structure, which is frequently obscured in the central parts by caseous necrosis.

The lung tissue generally shows some reaction in the neighbourhood of the tubercles. The alveoli are frequently occupied by catarrhal cells as in phthisis, and there is very often blood in them. The latter is so abundant in some cases as to give a very striking character to the sections. As the cases are very acute and death occurs early, we practically never find softening of the tubercles or formation of cavities.

Syphilis is a rare affection of the lungs, especially in adults. It is somewhat more common in new-born children, in whom it may be one of the manifestations of hereditary syphilis. In adults gummata have been observed in a few cases. They are surrounded by connective tissue in the usual way, and they may be partially softened so as to form cavities. The gummata are usually of small size.

White pneumonia is a name given to the condition met with in infants in congenital syphilis. It is a condition in which extensive tracts of lung tissue are condensed and infiltrated by a new-formation of connective tissue, the condition resembling that in chronic interstitial pneumonia (see Fig. 61, p. 185).

Actinomycosis, when affecting the lungs, presents lesions which may resemble those of tuberculosis somewhat closely. As in tuberculosis the microbe reaches the lung by the bronchi, and it sets up a bronchitis and lobular pneumonia. There is not a caseous necrosis of the products, but rather a more direct softening with fatty degeneration and suppuration, resulting in the formation of cavities. In other cases, however, the conditions may resemble those of fibroid phthisis, there being over an extensive tract of lung a new-formation of granulation tissue which develops into connective tissue and goes on to shrinking.

The disease tends to go beyond the lung to the pleura, pericardium, muscles of the chest, skin, etc. The peculiar microbe is present, and in some cases it has been distinguished in the expectoration.

Glanders may affect the lung by extension from the nares and air-passages, and possibly also by the blood. It leads to local inflammatory foci, which may be large or small. The inflammation is usually acute and abscesses result, but sometimes there is a more chronic affection with caseation and formation of cavities.

Literature.—*Syphilis*—VIRCHOW, Die krankhaften Geschwülste, ii., 1865; HILLER, Charité-ann., 1882, 1884; HELLER, Deut. Arch. f. klin. Med., 42, 1888; COUNCILMAN, Johns Hopkins Hosp. Bull., ii., 1891; FOWLER, Allbutt's System of Med., v., 1898; FLOCKEMANN (with literature), Centralb. f. allg. Path., x., 1899. *Actinomycosis*—LINDT, Correspbl. f. schweiz. Aerzte, 1889. *Glanders*—LECLANCHE et MONTANÉ, Ann. de l'Inst. Pasteur, vii., 1893.

XI.—TUMOURS AND PARASITES OF THE LUNGS.

Primary tumours of the lungs are infrequent. Hebbing relates a case of primary tumour replacing the left lung and which he calls a Rhabdomyoma, but which contained cartilage, gland elements, etc., as well as muscle.

Primary fibroma, osteoma, lipoma, and enchondroma have been observed in the form of small tumours, sometimes multiple. These are unimportant.

Primary cancer is a form of tumour which sometimes attains to considerable size. The growth seems to take origin in the mucous glands of the bronchi, and it usually retains somewhat of the glandular character throughout, presenting in many cases the features of the **Cylinder-celled epithelioma**. The tumour may, for a time at least, confine itself to the bronchi and their neighbourhood, simply infiltrating the peribronchial connective tissue, but it often extends to the parenchyma of the lung, forming in some cases bulky tumours. The cancer in the lung has a tendency to soften so as to form **Cavities**, in the wall of which cancerous tissue may be found. In some cases most of the cancerous tissue from the primary tumour may be lost by this process of softening, and the case may have the general aspects of a cavity in the lung with an edge in which, even with the microscope, it may be difficult to detect the proper tumour tissue, as it is greatly obscured by inflammatory products.

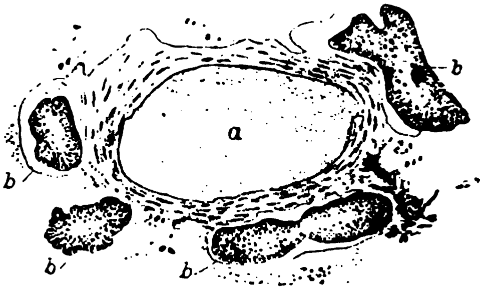

Fig. 552.—From a primary cancer of the lung, showing extension by the perivascular lymphatics. *a*, section of pulmonary artery ; *b*, *b*, cancerous growth in lymphatics.

In its extension the tumour sometimes penetrates into the lung alveoli. On the other hand, it often forms for itself alveoli similar in size to those of the lung, but of independent origin. It penetrates into the perivascular lymphatic spaces still more than into the lung alveoli, and may often be detected filling up these around the vessels as in Fig. 552. This appearance is sometimes visible a considerable distance in advance of the edge of the tumour.

The cancer sometimes extends to neighbouring structures such as e pericardium, the wall of the heart, etc.

rhe author has recorded a case in which a very peculiar secondary extension :urred to the bones and to the brain. In these two situations the tumours umed remarkable cystic tendencies, so that in the brain they were represented iefly by cysts (see Fig. 486, p. 778). These cysts occurred apparently by mucous colloid change, although in the primary tumour in the lung there was little :h change. The author has observed several other cases in which secondary nours have occurred in the brain and bones. In some of these the primary nour in the lung was only represented by a cavity with infiltrated walls, whose ture might have been readily overlooked.

Secondary tumours are somewhat frequent, either by direct exten- n from the neighbourhood or by embolism.

The lung is often involved by direct extension in **Lympho-sarcomas** the mediastinal and bronchial glands. The new-formation follows e connective tissue of the lung, and we find it penetrating in a liating manner from the root, often burying the bronchial tubes a sheath of new-formed tissue and partially or completely obstruct- g them (see Fig. 169, p. 336).

Of the tumours arising by embolism, sarcoma and cancer are the ief forms, although chondromas have also been known to extend to e lungs in this way.

Sarcomas, as we know, sometimes penetrate directly into the veins, d portions being carried to the right heart are caught in the branches the pulmonary artery or capillaries. The secondary tumours in the ng are multiple and they repeat exactly the structure of the primary ie. Thus we have giant-celled, round-celled, and spindle-celled rcomas. A tolerably frequent form is the pigmented sarcoma. The **ichondroma** also not infrequently undergoes secondary development, pecially in connection with tumours of the testis.

Cancers, as we have seen, do not readily penetrate into the veins rectly. Finding an easier path by the lymphatics they nearly always st develop in the lymphatic glands. After a time the cancerous ments may pentrate from the lymphatic sinuses in the gland into the ins, or they may possibly penetrate directly from the primary mour into the latter, and the material be carried on to the lungs. the cancer is usually arrested for a considerable time at the lym- atic glands, it happens that in all forms of cancer secondary tumours the lungs are of late development. As the secondary tumours are the lymphatic glands we may regard those in the lungs as of a tiary order.

It is clear that the lung is not a congenial situation for the growth of cancerous tumours, as they only occasionally attain to any considerable size (see Fig. 553). There is the most marked contrast in this respect between the lungs and the liver. There is not infrequently in the lungs abundant evidence of cancerous infection, but the actual cancerous growth almost limits itself to the lymphatics. Thus there may be visible under the pleura a network of a whitish colour consisting of lymphatics occupied by cancerous growth, whilst, on section, small white nodules are seen around the bronchi, which are the peribronchial and perivascular lymphatics filled with cancerous tissue.

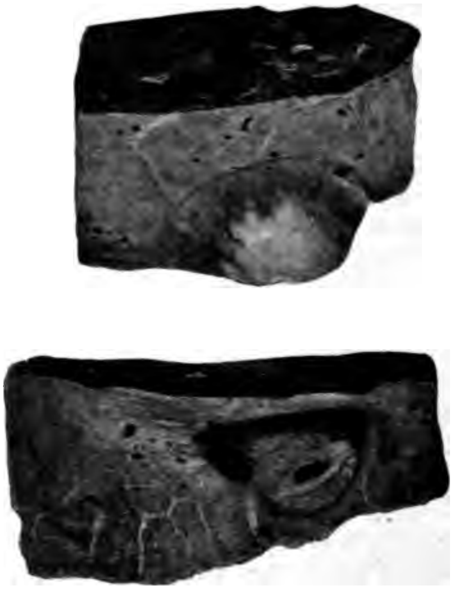

Fig. 553.—Secondary cancerous tumours in the lung.

The lungs may give passage to the cancerous infection whilst themselves unaffected, or only to the slight extent mentioned above. There may thus be a generalization of the cancer without any definite tumours in the lungs.

An interesting demonstration of the conditions referred to above was afforded in a case which occurred to the author, and which may here be briefly related. It illustrates as well the tendency of the cancerous growth to penetrate into existing spaces and canals. The primary tumour was a cancer of the stomach and secondary growths had occurred in the prevertebral glands. One of these glands was adherent to the vena cava, and several radicles of this vein emerged from the midst of cancerous glands. Actual cancerous thrombi of some of these veins were detected by the naked eye, and under the microscope it was seen that the cancerous masses had partially penetrated into the venous radicles in the glands. On examining the lungs with the naked eye it could be seen from the surface that the new-formation was largely in the lymphatic vessels which were visible as a white network. On section the arteries were usually seen to be surrounded by new-formed tissue. Under the microscope the finer branches of the pulmonary artery were found to be frequently obstructed. The obstructing material was not entirely cancerous in structure, but there was often a round-cell formation with now and again a distinctly cancerous appearance. In most cases the obstruction was complete. Outside the obstructed arteries there were spaces and canals filled with cancerous growths, as shown in Fig. 554. These were obviously the lymphatic channels of the sheath of the vessels into which the cancerous formation had penetrated, just as it does in primary cancer (see Fig. 552).

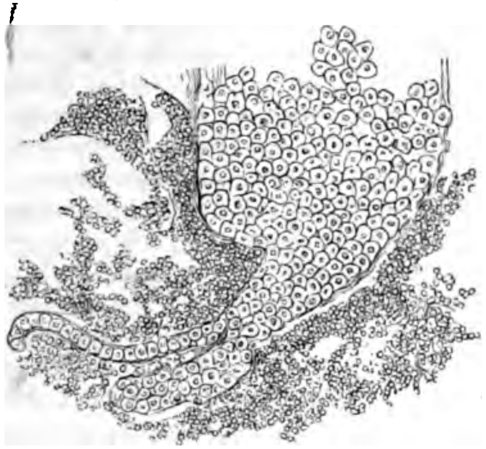

Fig. 554.—Embolic cancer of lung. One of the spaces filled with epithelial cells. There is a larger space with two branches into which the epithelial cells have extended. × 90.

Deciduoma malignum in its later stages frequently shows metastases in the lungs (see Fig. 555).

Parasites in the lung.—These are of very rare occurrence, unless we include microbes which have already been considered. A fungus of the **Aspergillus** form has been found in a few cases, in cavities, and in the expectoration in some cases (*Mycosis of the lung*).

Of animal parasites, **Echinococcus** is most frequently seen. There may be perforation of the cyst into bronchus, pleura, or peritoneum. The parasite is generally situated in the lower lobe. Cysticercus cellulosæ has also been observed.

Amongst rare parasites in the lung may be mentioned one case of a long round worm, the *Strongylus longevaginatus*, found in a child six years of age (Diesing). It is also said that in Egypt the eggs of distoma hæmatobium are found in the interstitial tissue. The *distoma pulmonale* is a frequent parasite in Japan. The worms are about three eighths of an inch in length, and their eggs appear in the sputum of the patients, which also contains blood (see p. 420).

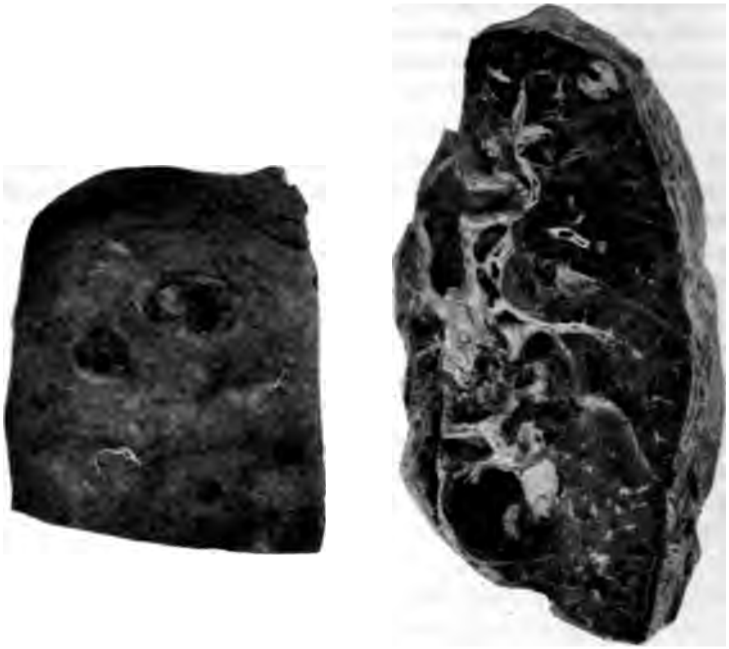

Fig. 555.—Metastases in the lungs in deciduoma malignum. On the left the pleural surface is shown.

Literature.—*Tumours*—ROKITANSKY, Handbuch, iii.; VIRCHOW, Geschwülste, ii.: HEBBING, Centralb. f. allg. Path., ix., 434, 1898; EBERTH (Cancer), Virch. Arch., xlix.; LANGHANS, ibid., liii.; PERLS, ibid., lvi.; WEICHSELBAUM, ibid., lxxxv.; FINLAY and PARKER, Med. Chir. Trans., lx.; MARCHIAFAVA, Riv. clin. di Bologna, 1874; COATS, Path. Trans., 1888, xxxix., 326. *Parasites. Mycosis*—VIRCHOW, Virch. Arch., ix. and x.; FÜRBRINGER, ibid., lxvi.; RENON, Étude sur l'aspergillose, Paris, 1897 (Bibliography). *Echinococcus*—THOMAS, Brit. Med. Jour., 1885, ii., 692; LAVERAN, Kyst. hydat. des poumons, 1885; LENDON, Clin. Lects. on Hydatid disease of the lungs, 1902. *Round worms*—MANSON, Lancet, 1883; BAELZ, Berl. klin. Wochenschr., 1883. Die Krankh. d. Athemorgane, Tokïo, 1890; YAMAGIWA, Virch. Arch., cxix., 1890.

E.—THE PLEURA.

1. **Affections of the circulation.**—There can scarcely be any independent circulatory disturbances in the pleura. **Hyperæmia** exists in cases of severe dyspnœa, and this may result even in subpleural hæmorrhages, producing **Petechiæ**, which are regarded as of diagnostic significance in death from suffocation (see p. 813).

Hæmorrhage into the pleural sac arises as a result of wounds, rupture of aneurysms, and sometimes from tubercular or cancerous new-formations in the pleura, more particularly the latter.

Hydrothorax is a dropsy of the pleural sac. Hydrothorax of local origin is brought about by conditions which obstruct the veins or lymphatics. It is induced not infrequently by malignant tumours of the mediastinum or of the pleura itself. It is frequently part of a general dropsy, as in Bright's disease, cardiac disease, or anæmia. The exudation consists of clear watery fluid. It is often limited by adhesions, which latter may also be dropsical. The lung is compressed in proportion to the amount of fluid.

Chylous hydrothorax is a rare form, arising from rupture of the thoracic duct (see p. 101).

2. **Inflammations of the pleura. Acute pleurisy.**—We have seen that whenever any form of inflammation comes to the surface of the lung it causes inflammatory changes in the pleura; there is acute pleurisy in acute pneumonia and in caseous phthisis, and chronic pleurisy is a constant accompaniment of all forms of phthisis pulmonalis. On the other hand, the pleura seems to have intimate connections with the peritoneum, as there are lymphatic channels passing through the diaphragm which form communications between the two sacs, and so pleurisy often follows on peritonitis.

These channels are doubtless intricate and narrow, so that the diaphragm acts to a certain extent as a barrier between the two sacs, but it is not sufficient to prevent the passage, for instance, of the tubercular virus from the one to the other. A tubercular peritonitis is nearly always accompanied by a tubercular pleurisy, usually limited to the lower parts of the sac. Similarly a septic peritonitis is frequently followed by a pleurisy. Tumours of the peritoneum also frequently lead to similar formations in the pleura.

Besides these we may have pleurisy occurring in the course of some acute diseases, such as acute rheumatism, pyæmia, etc. In addition to these there seems to be a more independent pleurisy, produced, as it is said, by cold. Whilst cold applied to the chest may doubtless lead to a pleurisy, yet it is probable that many cases of apparent simple pleurisy either owe their origin to tuberculosis of the lung (*vide ante*) or are themselves tubercular in character.

There is often a pleurisy occurring in a limited area, just where the pleura is most directly exposed to the effects of cold, namely, in the left lower lateral region. In this position the chest is not covered by any considerable layer of muscles, as the fleshy masses of the latissimus dorsi and pectoralis major passing upwards to the arm leave, as it were, an unprotected space covered by the comparatively thin origins of the serratus magnus and external oblique muscle of the abdomen. This part is also removed from the centre of heat in the heart, and on the left side instead of the liver there is the hollow stomach. On the right side the liver is a source of heat, and renders the corresponding part on this side less exposed to cold than that on the left, but still more exposed than most other parts of the chest. It is probable that, in these localities especially, cold, acting directly on the chest wall, may cause an inflammation of the pleura by depressing the temperature.

In its **Anatomical details** acute pleurisy is closely analogous to acute pericarditis. There is hyperæmia, soon followed by a thin fibrinous deposit. This fibrinous exudation forms at first a soft yellow layer, which often attains to a considerable thickness, and later shows shaggy projections from the pleural surface especially in the region of the lower lobe. Serous fluid is also exuded, sometimes in considerable abundance. The exudation in some cases is hæmorrhagic in character.

When the acute inflammation subsides there may be a new-formation of vascular granulation tissue which may come to replace the fibrine. If two such surfaces come into contact, by absorption of the serous fluid or otherwise, coalescence and complete union of the surfaces occur, and the granulation tissue afterwards develops into connective tissue. We have already seen that the fluid accumulated in the pleural sac frequently compresses the lung greatly, producing collapse.

Empyema is a suppurative inflammation of the pleura. It may develop from an ordinary pleurisy or the inflammation may be suppurative from the outset. In the latter case there has usually been some specially virulent irritant present in the pleura, as where a metastatic abscess in the lung has approached the pleura, or where pleurisy is one of the phenomena of septicæmia. In these cases the disease is generally rapidly fatal, and we may find remains of the fibrinous exudation mixed with abundant pus.

Where the suppuration has come on in the course of a simple pleurisy the disease is often greatly prolonged, and the pleura undergoes great thickening, being converted into a bulky layer of granulation tissue like the wall of an abscess. The granulation tissue may undergo partial transformation into connective tissue with occasional adhesion, and, as the lung has been compressed by the exudation, we may have, should the pus be discharged or partially absorbed, drawing together of the chest to an extreme degree. The pus may dry-in instead of being discharged or absorbed. In that case it is, in course of time, impregnated with lime salts, so that considerable masses of calcareous matter may be found free in the pleura or embedded in adhesions. Very striking results are sometimes brought about in this way. The lung may be in great part surrounded by a cuirass of flat calcareous plates.

3. **Chronic pleurisy and Pleural adhesions.**—We have already seen that an acute pleurisy may result in adhesion of the sac, the process of adhesion resulting from coalescence of the surfaces which have become like granulation tissue from the inflammation. Such adhesion will not occur so long as fibrine is present on the surface, and it is to be carefully distinguished from the mere glueing together which may occur in the earlier stages from the adhesion of the fibrinous exudation on opposed surfaces. We have also seen that in the frequent chronic pleurisy of phthisis a similar adhesion occurs, and the method of its formation is similar. Without any fibrinous or serous exudation the surfaces come to have the characters of granulation tissue, and coalescence with vascular communication occurs.

4. **Tuberculosis of the pleura.**—This manifests itself chiefly as an inflammation of the pleura, and hence is identical with **Tubercular pleurisy**. The tubercle bacillus does not usually reach the pleura directly from the lung in phthisis pulmonalis, the pleurisy associated with phthisis being usually non-tubercular. On the other hand, the infection may reach the pleura by a local extension from the pericardium or peritoneum, from a tubercular lymphatic gland at the root of the lung, or from a tubercular abscess in connection with the vertebræ. It may also be conveyed by the blood.

Tuberculosis generally manifests itself at first as an acute or subacute inflammation, accompanied by abundant fibrinous exudation, sometimes mixed with blood. The tubercles are buried under the exudation, which may be very tough, and they may escape detection unless the fibrine be peeled off. They are often best seen between the lobes of the lung, where the close contact of the surfaces hinders the deposition of fibrine, and here they are visible as closely-set white nodules. The inflammation may go on to suppuration, so that we may have an empyema.

The acute character usually subsides after a time, and, with chronic inflammation, new-formation of connective tissue occurs, forming firm adhesions in the midst of which the tubercles may be found. As in the case of tubercular pericarditis, the adherent and coalesced pleura will show two layers of tubercles, one belonging to the visceral and the other to the parietal layer.

There may be a partial extension of the tuberculosis into the lung, along the interlobular septa, but it is a very superficial process.

5. **Pneumothorax.**—This has been referred to in connection with phthisis pulmonalis, and the mode of origin there indicated is that in the great majority of cases. Of the remainder there are some in which it is due to empyema—the visceral pleura having softened and the lung

having become ulcerated so as to communicate with the pleura,—and others in which it is due to gangrene of the lung, or to metastatic abscesses, or to the bursting of emphysematous vesicles, or to a traumatic cause.

The air in the pleural cavity is usually at a high pressure and the cavity is much distended, so that when the chest is opened the air rushes out with some force. The pleural cavity as exposed presents a remarkably empty appearance, the lung being compressed except where there are adhesions, which may form tense bridges across from parietal to visceral layer or may limit the pneumothorax considerably. If the patient live there is nearly always an acute suppurative pleurisy, so that the condition may be designated **Pyo-pneumothorax.**

Experimental observation seems to show that the air may be absorbed, and this is confirmed by actual clinical observation.

6. **Tumours of the pleura.**—Primary tumours are rare, but cases of osteoma and of lipoma have been recorded.

Primary cancer occurs in the pleura, forming, according to some, **Endothelial cancer** or **Endothelioma.** In most of the recorded cases there has been great thickening of the pleura and the tumour formation was in some apparently related to the lymphatics. The pleura has usually contained a bloody fluid and has been coated with coagulum sometimes with the appearance of acute pleurisy. In some cases there has been metastasis to other organs.

In a case observed by the author there were numerous tumours on the pleura, and also, by coalescence, larger masses, forming a layer of considerable thickness. The tumours were almost continuous over the pleura, and there was no tumour anywhere else. The sac was greatly distended with a blood-coloured fluid, measuring 140 ounces, which had deposited a loose brown coagulum. During life the case resembled one of acute pleurisy with great effusion. Paracentesis was twice performed, and a bloody fluid withdrawn.

Microscopic examination showed the tumour to be a superficial cancer of the pleura. There was the usual stroma enclosing epithelial cells, which were frequently fatty. The tumours were not at all deep in the substance of the pleura, there being always a layer of connective tissue beneath them. (See Glasg. Med. Jour., July, 1889.)

SECTION VI.

DISEASES OF THE THYROID AND THYMUS GLANDS AND OF THE SUPRARENAL BODIES.

A.—The Thyroid Gland.—1. Inflammation; tuberculosis; syphilis. 2. Exophthalmic goitre; Graves' or Basedow's disease. 3. Simple goitre or Bronchocele; consists of hypertrophy and adenoma; colloid change usually present; fibrous induration and calcification; goitre with secondary tumours. 4. Tumours.

B.—The Thymus.—Its various diseases.

C.—The Suprarenal Bodies.—Chiefly Addison's disease.

A.—THE THYROID GLAND.

THE thyroid gland consists of saccules of various shapes lined with epithelium. In these saccules there is often a little clump of colloid matter, the amount of which varies within normal limits. The gland has no duct, and its secretion presumably passes into the blood by the lymphatics or the veins. This secretion has evidently a most important function in the animal economy as excision or atrophy of the gland leads to a serious train of symptoms (see under Myxœdema).

1. **Inflammation** of the thyroid gland (**Thyroiditis**), resulting sometimes in suppuration, may arise from injury, from septic infection, or from other less obvious causes. Its occurrence has been noted during the course of enteric fever, diphtheria, and acute rheumatism. **Tuberculosis** of the gland is not very uncommon in cases of general tuberculosis. The tubercles are usually few in number and small in size (see Fig. 556). Large caseating masses, causing actual enlargement of the gland (*Tuberculous goitre*) are occasionally seen.

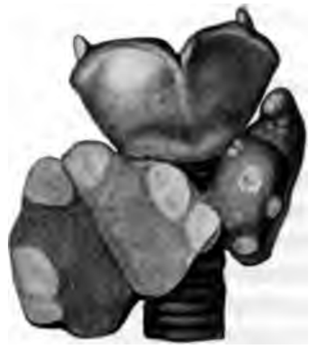

Fig. 556.—Tuberculosis of the thyroid gland of a child.

Syphilis very rarely affects the thyroid gland. **Gummata** have been observed in a few instances.

The principal diseases of the thyroid gland are associated with enlargement, and to these names **Goitre** and **Struma** are applied.

2. **Exophthalmic goitre** (*Graves' disease*, *Basedow's disease*).—This disease has already been considered (see p. 236).

3. **Simple goitre. Bronchocele** (also called in German *Struma* and *Kropf*).—This disease consists in an enlargement of the thyroid gland, which, occurring as it does chiefly in certain specific localities, has been ascribed to some **Miasma**. Within recent times a hæmatozoon has been found in the blood of goitrous patients (Grasset). The enlargement of the gland may be uniform, but in many cases it is unsymmetrical, as in Fig. 557.

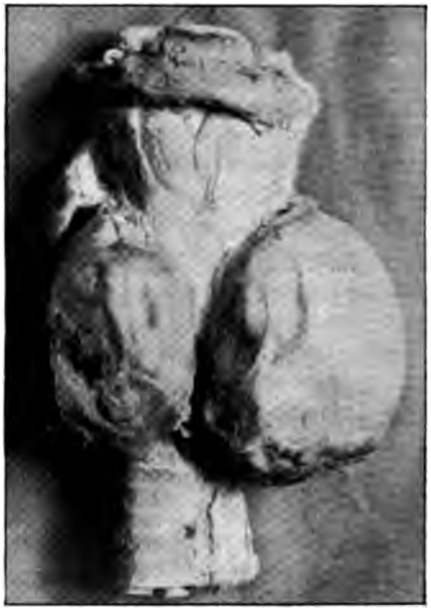

Fig. 557.— Goitre. There is enlargement chiefly of the left lobe of the thyroid.

The lesion in ordinary goitre is primarily an increase of the normal gland tissue. This has sometimes the characters of a simple **Hypertrophy**, the saccules being multiplied. In other cases the new-formed tissue is discontinuous, occurring in the form of separable tumours in the midst of the gland (Fig. 153, p. 319). To this form the name **Adenoma** is given. In many cases hypertrophy and adenoma co-exist.

In both forms the tissue is liable to secondary changes. An almost constant condition is colloid degeneration. Some saccules nearly always in colloid matter, and in many cases there are many saccules ly enlarged and distended with this substance. When this is ient to give a character to the naked-eye appearances the term id goitre is used. Some of the altered saccules may assume pre- erating dimensions so that **Cysts** develop.

e affected gland not infrequently undergoes **Fibrous induration**; apsule and the connective-tissue septa become thickened. In the t of the fibrous tissue pieces of gland tissue which have under- necrosis may be visible. In such indurated glands calcification nonly ensues, especially in necrosed parts. A true ossification has been observed.

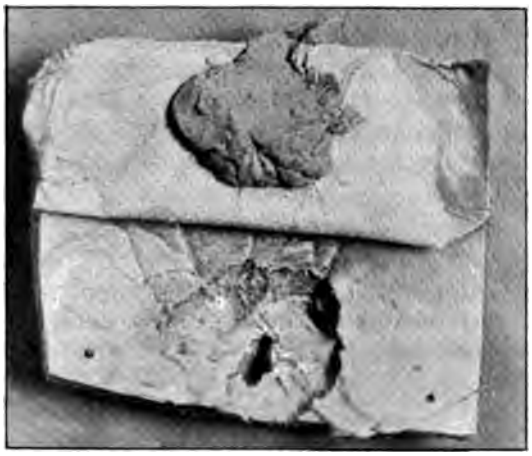

Fig. 558.—Secondary tumour in skull from case of goitre. The dura mater is aised and has carried the tumour tissue with it. The bone is eroded, and in one lace perforated.

itre is usually a simple affection, but a few cases are on record in h secondary tumours developed, chiefly in the bones. In a case ved by the author there were several such tumours in the bones e skull, which presented the typical structure of the thyroid l. The figures in the text are all from this case. Fig. 557 sents the thyroid enlargement, and shows the macroscopic rance of the goitre. Fig. 558 shows a tumour of the parietal which had eroded the bone. In Fig. 559 the microscopic structure e tumour is given and the saccules of thyroid tissue lined with elium are shown.

Tumours of the thyroid gland.—**Cancer** is not very uncommon. curs chiefly as an ordinary glandular carcinoma, but also as a der-celled tumour. **Sarcoma** also occurs. Wölfler has observed, besides the ordinary round-celled tumour and spindle-celled forms, a true giant-celled sarcoma. In a case of round-celled sarcoma observed by the author there were two large cysts, and the tumour extended down into the chest as far as the pericardium. It also incorporated the anterior wall of the trachea.

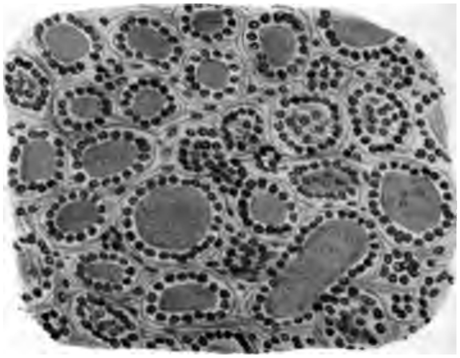

Fig. 559.—Section of a secondary tumour in bone in a case of goitre. × 300.

Literature.—*Inflammation*—Kocher, Deutsche Zeitschr. f. Chir., x., 1878; Brieger (Diphtheria), Charité-ann., viii., 1883; Jeanselme, Gaz. des Hôp., 15, 1895. *Tuberculosis*—Chiari, Med. Jahrb., Wien, 1878; Brun's Beiträge z. klin. Chir., x., 1892 (literature). *Syphilis*—Barth et Gombault, Progrès méd., 1884. A very full account of Goitre and Tumours, with many illustrations by Wölfler, in Langenbeck's Arch., xxix., 1883; Virchow, Krank. Geschwülste, iii.; Gutknecht, Virch. Arch., xcix.; Bircher, Der endemische Kropf, 1883; M'Kenzie, Glas. Med. Journal, li., 1899; Grasset (Hæmatozoa), Brit. Med. Jour., ii., 1898. *Goitre with secondary tumours*—Cohnheim, Virch. Arch., lxviii., 1876; Morris, Path. Trans., xxxi., 1880; Coats, ibid., xxxviii., 1887; Oderfeld und Steinhaus, Centralb. f. allg. Path., xii., 209, 1901. *Tumours*—Bircher, in Volkmann's Sammlung, No. 222; Coats, Catal. of Pathological Museum, Western Infirmary, Glasgow.

B.—THE THYMUS GLAND.

The thymus gland is situated in the upper part of the anterior mediastinum, extending up in front of the trachea nearly as high as the thyroid gland. It attains its largest size about the second year of life, remains stationary from that time till the fourteenth year, and then gradually atrophies. The atrophy is associated with an infiltration of adipose tissue. By some the gland is regarded as lymphatic in structure and function, but embryologically it seems to have an epithelial origin. It contains round bodies which are sometimes calcified—the so-called **Concentric bodies of Hassall.**

The thymus is liable to **Inflammations** like other glands. **Hyper- rophy** also occurs, and cases of asthma and of spasm of the glottis sulting sometimes in sudden death have been ascribed to this con- ition, but without sufficient evidence.

Enlargements occur in **Leukæmia** and in **Hodgkin's disease**, the lation of the organ to the spleen and lymphatic glands being thus dicated.

Tumours also occur, chiefly sarcomas, and cancers.

Syphilis sometimes manifests itself by the presence of gummata. **uberculosis**, according to Jacobi, is not of infrequent occurrence, both a local affection and in general tuberculosis.

Literature.—Sanné, in Dict. encycl. des sc. méd., Article Thymus, 1887; Jacobi, omptes rendus du Congrès pour l'étude de la tuberculose, 1888, and Anat. and ath. of thymus, Trans. Assoc. of Amer. Phys., Sept., 1888.

C.—THE SUPRARENAL BODIES.

The function of these bodies is quite obscure, but some writers, on resumed analogy with the thyroid gland, have supposed that they ecrete some substance necessary for the economy. With a few excep- ions their diseases are of minor importance. **Accessory suprarenal odies** in the form of small ochre-yellow nodules or plaques are requently found in connection with the kidneys (see Tumours of idney). They occur also in the neighbourhood of the main supra- enal bodies, in the liver, along the course of the renal and spermatic eins and in the broad ligaments.

Addison's disease is demonstrably connected in the great majority of ases with disease of the suprarenal bodies (see p. 241). The disease is a **ocal tuberculosis**. The suprarenal glands are enlarged, and their tissue replaced by caseous matter and fibrous tissue. Usually the whole rgans are transformed, and no recent or recognizable structures may e found, but if the condition be not so advanced, then ordinary ubercles are visible, and the disease is seen to be tubercular. Besides he lesion in the suprarenal bodies there is matting and contraction of he tissues outside them, involving the important nerve structures, the emilunar ganglia, etc., in the neighbourhood.

Tumours are not frequent in the suprarenal bodies. Certain of these eproduce more or less typically the structure of the organ and are egarded as **Adenomas** (see Fig. 154, p. 319). *Struma lipomatosa supra- enalis* is a name used by Virchow for a simple enlargement composed of suprarenal tissue rich in fat. **Cysts**, hæmorrhagic or serous, are sometimes found in connection with the suprarenal glands (see Fig. 560).

Ganglionic neuromas have been observed in very rare instances. Primary **sarcoma** is an occasional tumour. A case of primary double sarcoma is recorded by Affleck and Leith, who also give references to two other cases seen by Leith and to sixteen recorded cases. The case given showed cells of various sizes, many multinucleated. There were secondary tumours in various regions. Most recorded cases are spindle-cells; some have been cystic. A case of bulky spindle-celled sarcoma is recorded by the author. Cases of **primary cancer** have been reported by a number of observers. Histologically the growths often closely resemble sarcomas. Secondary cancer in the form of isolated nodules is not uncommon when generalization of cancer has occurred (see Fig. 561).

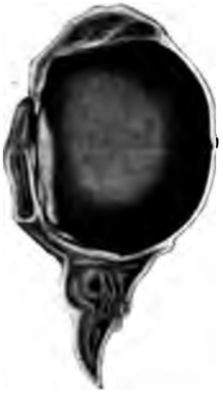
Fig. 560. Cyst of the suprarenal body, a large amount of osseous tissue was found in the wall.

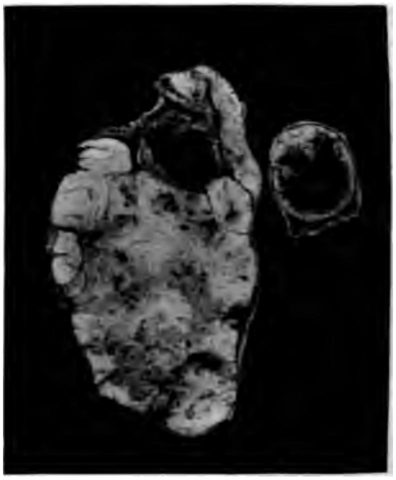
Fig. 561. Secondary cancer of suprarenal bodies. The growths are shown in section.

In addition the organs are liable to the usual pathological changes, but these are chiefly secondary to affections of other organs. Thus we have inflammation, hæmorrhage, fatty degeneration, amyloid degeneration, etc.

Literature.—ADDISON, On the constitutional and local effects of disease of the suprarenal capsules, London, 1854; GREENHOW, On Addison's disease, 1875, also Trans. Internat. Med. Cong., London, ii., 1881; VON KAHLDEN, Virchow's Arch., 114, 1888; LUBARSCH, Ergebnisse d. allgem. Path., etc., iii., 1896 (literature); ROLLESTON, Brit. Med. Journ. i., 1895, also Allbutt's System of Med., iv., 1897. *Tumours*—AFFLECK and LEITH, Edin. Hosp. Rep., 1896; COATS, Glas. Med. Jour., 1872; KELLY, Ziegler's Beiträge, xxiii., 1898; OBERNDORFER (adrenal tissue in Liver), Centralbl. f. all. Path., xi., 1900; WOOLLEY, American Journ. Med. Sciences, Jan., 1903.

SECTION VII.

DISEASES OF THE ALIMENTARY CANAL.

A.—**The Mouth.**—I. **Malformations and retrograde changes.** II. **Inflammations.** **1. Catarrh**, 2. Thrush, 3. Special inflammations, 4. Cancrum oris, 5. Glossitis. **III. Infective and other tumours**—Syphilis, Tuberculosis, Tumours proper. **IV. Affections of the Teeth**—1. Caries, 2. Inflammations about the teeth, 3. Syphilitic teeth, 4. Tumours connected with the teeth.

B.—**The Soft Palate, Pharynx and Tonsils.** 1. Malformations, 2. Catarrhal angina, 3. Phlegmonous inflammation, 4. Diphtheria, 5. Acute tonsillitis, 6. Chronic tonsillitis, 7. Syphilitic disease, 8. Tuberculosis, 9. Tumours.

C.—**The Œsophagus.** 1. Dilatation, (*a*) General Dilatation, (*b*) Partial dilatation, including Pulsion-Diverticulum and Traction-Diverticulum, 2. Obstruction, 3. Inflammation—Syphilis—Tuberculosis, 4. Rupture and perforation, 5. Tumours.

D.—**The Stomach.** Introduction and post-mortem changes. I. **Malformations and Contractions.** II. **Dilatation and Hypertrophy.** III. **Inflammations**, including catarrh and effects of corrosives and poisons. IV. **Simple perforating ulcer**—Characters; Effects and modes of origin. V. **Hyperæmia and Hæmorrhage.** VI. **Tuberculosis and Syphilis.** VII. **Tumours**, principally Cancer. Structure and mode of growth of cancers. Forms—1. Cylinder-celled epithelioma, 2. Soft cancer, 3. Scirrhus, 4. Colloid cancer.

E.—**The Intestines.** Introduction and post-mortem changes. I. **Malformations.** II. **Embolism and Hæmorrhage.** III.—**Hernia**—Causation; Structure of sac; Forms of external and internal hernias; Contents; Irreducible hernia; Strangulation. IV. **Twisting.** V. **Intussusception and prolapse.** VI. **Inflammations**—1. Catarrh, 2. Phlegmonous and diphtheritic inflammations, 3. Localized inflammations, especially appendicitis. VII. **Specific Inflammations**—1. Dysentery, 2. Cholera, 3. Typhoid fever, 4. Anthrax, 5. Actinomycosis. VIII. **Tuberculosis and Syphilis**, chiefly the tubercular ulcer. IX. **Retrograde changes and abnormal contents.** X. **Tumours**, chiefly cancer. XI. **Obstruction of the Intestine**—Some unusual causes; Effects, including stercoraceous vomiting.

INTRODUCTION.—The alimentary canal is lined throughout by a mucous membrane, which consists of loose connective tissue overed with epithelium in one or several layers. In the mucous membrane, and to some extent beneath it, are glands which in different parts have different structures, but everywhere secrete materials that pass into the canal. In addition to these there are in many parts closed follicles of a lymphatic structure which usually lie near the surface and frequently take part in changes going on there. Beneath the mucous membrane is the submucous tissue which, for the most part, is loose, and so allows the mucous membrane to go into folds or be stretched out flat according to the state of dilatation or contraction of the canal. Outside this there is a muscular coat, generally in two layers by means of which movements and variations in calibre are effected. In most parts of the intestinal canal there is a limiting serous coat.

In the diseases of the alimentary canal it is chiefly the mucous membrane that we have to deal with, the subjacent structures being usually subordinate and affected secondarily. The serous coat, it is true, is often affected independently; its diseases, however, do not belong specially to the alimentary canal, but to the peritoneum as a whole. The mucous membrane, on account of its exposure to a variety of influences derived from the varying contents of the canal, is specially liable to inflammation, and the great majority of the diseases to be considered here are inflammatory.

A.—THE MOUTH.

As the mouth is exposed in a special manner to external influences, its mucous membrane possesses an epithelium in many layers, and it is not nearly so liable to inflammation as are most other parts of the alimentary canal. It is to be noted that even extensive wounds of the mouth do not commonly take on a septic character.

I.—MALFORMATIONS AND RETROGRADE CHANGES

Malformations of the mouth are represented by **Cleft-palate** and **Hare-lip**, which have been already referred to at p. 53.

Atrophy of the tongue is a regular result of bulbar paralysis when the nucleus of the hypoglossal nerve has been involved, as is usually the case. **Hemiatrophy** is a much more rare lesion. It occurs for the most part in consequence of interference with the hypoglossal nerve in its course by wounds, tumours, disease of bone, etc. It has also been observed in cases of locomotor ataxia in which there may be a lesion of the nucleus of the hypoglossal nerve.

Amyloid degeneration is not very uncommon, affecting the vessels. It has been observed in the form of nodular tumour-like masses. The muscular and glandular tissue undergo atrophy in the affected regions. **Fatty infiltration** of the tongue is not infrequent in emaciating diseases.

iterature.—Erb (with literature), Deutsch. Arch. f. klin. Med., xxxvii., 1885; ymond et Artaud (atrophy in tabes), Arch. de Physiol. norm. et path., 1884; gler (amyloid disease), Virch. Arch., lxv., 1875.

II.--INFLAMMATIONS OF THE MOUTH. STOMATITIS.

1. **Catarrh.**—If we leave out of view the catarrhs of the fauces and arynx, which we consider afterwards, **Simple catarrh** of the mouth exceedingly rare as a primary disease. It is not infrequent, however, a secondary affection, arising from the irritation of carious teeth, m the use of mercury, the presence of ulcers, etc. It is also of quent occurrence in the acute fevers, especially typhus, scarlet fever, all-pox, and measles. In these fevers there is also a catarrh of the omach, and the inflammation in both seems due to the action of the orbid poison in the blood.

The mucous membrane is swollen and red and there is greatly creased desquamation of the epithelium, especially inside the cheeks d on the tongue. The desquamated epithelium is mixed with leucotes, serous exudation, and mucus in varying proportions, and on that count it has varying characters. On the tongue there is usually uch epithelium which lies on the surface, and so a tolerably thick yer is formed mostly of a whitish or yellowish colour—**Furred tongue.** n the cheeks and gums there is more fluid and less epithelium, nd consequently less tendency to the formation of deposits. In the idst of the epithelium and leucocytes bacteria and leptothrix and ngus threads are to be found, indeed, the thick deposit on the furred ngue is largely composed of microbes of many kinds. If the patient feverish and lies with the mouth open, the catarrhal products dry in d form a dirty brownish coating of the tongue and gums which goes nder the name of **Sordes.**

Sometimes the inflammation centres especially around the mucous lands, and they may form prominent nodules or vesicles. To this rm the name **Follicular stomatitis** has been given; it is frequently en in children during dentition or after measles, and is often associated ith catarrh of the stomach or intestine. The vesicles or small prominnces frequently burst and leave multiple small ulcers covered by a irty exudation.

Catarrh of the mouth rarely assumes a phlegmonous character, in his respect contrasting with inflammation of the fauces.

2. **Thrush, or Aphthous stomatitis** (*The Soor of the Germans*).—This ffection is associated with the presence of a fungus—the **Oïdium lbicans.** It occurs chiefly in the mouths of young unhealthy children, but is also occasionally seen in emaciated adults, as in diabetes. The

normal secretion of the mouth is alkaline, but in this disease it becomes acid, which may perhaps be the reason that the fungus develops. The mucous membrane is found beset with small white spots, which look like small portions of white curd on the surface. These patches are, however, adherent, and on removing them the mucous membrane beneath will be found red and bleeding. The white patch consists of epithelium united into a membrane by the fungus, the oïdium albicans (Fig. 562). It consists of branching threads composed of elongated cells placed end to end and sometimes losing themselves in masses of spores. The aphthous patches frequently extend from the mouth downwards to the pharynx and œsophagus.

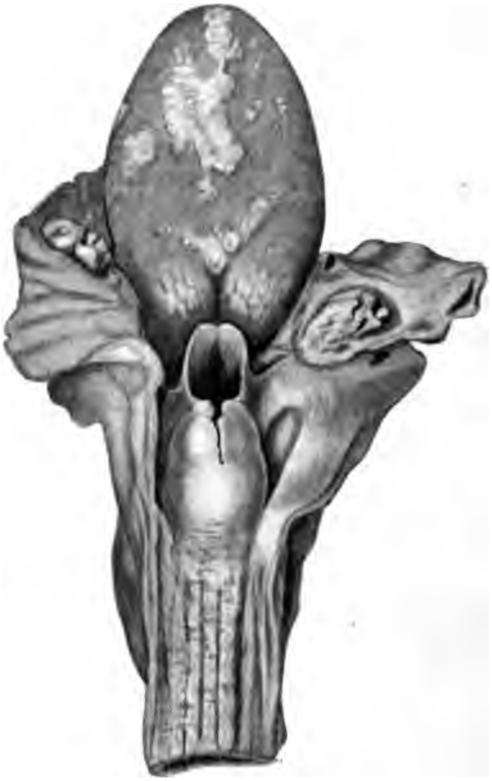

Fig. 562.—Thrush affecting the tongue and œsophagus in a child the subject of extensive tuberculosis.

3. **Special forms of inflammation.**—In **Small-pox,** besides the general catarrh of the mouth already mentioned, there are vesicles or pustules analogous to those on the skin. We have first whitish patches consisting of raised and desquamating epithelium. The epithelium is

on discharged, and superficial ulcers result. In **Scurvy** there is great elling and œdema of the mucous membrane of the gums around the eth. The gums bleed, and, apparently as a consequence of this, cers form around the teeth and may extend down to the bone, hich may undergo necrosis. Very often the teeth are loosened. s a consequence of the **use of mercury** we sometimes have a severe omatitis. It occurs mainly after the medicinal use of mercury, but so among workmen who make use of it in their occupations. The ucous membrane is swollen, especially that of the gums and cheeks, d there is severe salivation. Ulcers frequently form, especially on e internal surface of the cheeks and lips, and on the edges of the ngue. They may be in the form of flat excoriations or deeper ulcers ith a membranous covering.

4. **Cancrum oris, Noma, or Gangrenous stomatitis.**—This disease, hich is fortunately a rare one, occurs in badly nourished children, rticularly when reduced by severe illness such as scarlet fever or easles. It presents itself first as a diffuse swelling of the cheek which seen to be tense, red, and glistening, with one spot in the centre ually redder than the rest. On examining the inside of the mouth ere is already an excavated ulcer opposite the red spot on the cheek, d the gums opposite may also be ulcerated. As the disease rogresses more and more of the mucous membrane of the mouth is lcerated away. At the same time the red spot on the cheek becomes lack in the centre, and afterwards extends in area. By and by a ough, which varies in size, separates and a communication forms rough the cheek with the inside of the mouth. If the patient rvive, still further destruction occurs, the necrosis passing on to the rrounding skin of the face, even to the ear and eyelids. There may necrosis of the jaws. Not infrequently this disease is associated th a gangrenous pneumonia and there are general symptoms of tic poisoning.

The disease advances by a progressive necrosis, so that in a section ough the advancing edge there is in the parts already necrosed absence of nuclear differentiation. This is bounded by a highly lular area evidently from inflammation. It is apparent that the rbific agent produces necrosis almost directly, but in front of its vance it also leads to inflammation, which is not very great.

The author found, in addition to the usual microbes of decomposition the sloughing surface, a very remarkable growth of a bacillus into necrosed, but otherwise unaltered tissue. The microbe was in the m of long threads, occasionally with evident spores, and it extended large numbers to the very edge of the necrosis, and to a very slight extent beyond it into the inflamed part. The bacillus was apparently anaërobic, growing into the tissue away from the surface. It was readily stained by Gram's method, but not by ordinary watery solutions.

5. **Inflammation of the tongue** deserves a brief special notice. We have seen that the tongue takes part in most of the inflammations of the mucous membrane, but sometimes it becomes the seat of a special inflammation of its substance, a true **Glossitis**. This may occur as a result of wounds or irritations from without, or in the course of such diseases as erysipelas and small-pox. The tongue swells greatly in consequence of the inflammatory infiltration of the interstitial connective tissue, and this sometimes, though rarely, goes on to the formation of abscesses. The muscular fibres are swollen, pale and brittle. Usually the inflammation ends in resolution, but sometimes it becomes chronic, and there may be great increase of connective tissue with permanent induration of the tongue.

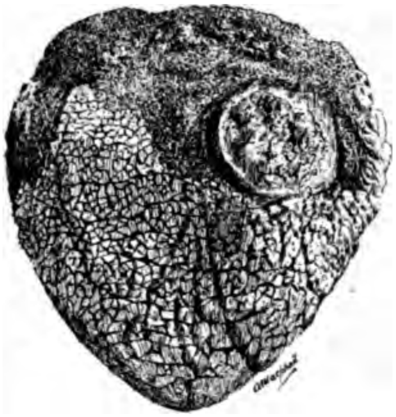

Fig. 563.—Cancer occurring in a tongue the seat of leucoplakia. (From a drawing by Dr. ALEX. MACPHAIL.)

6. **Leucoplakia** (Leucoma, Psoriasis, Tylosis, Keratosis).—A not infrequent result of chronic glossitis is the occurrence of bluish-white or pearly patches or plaques on the surface of the tongue. As a rule they are smooth, but sometimes their surface is warty (*Ichthyosis linguæ*). They are generally referred to some irritating cause, and are frequently seen in smokers, but doubtless some are more predisposed than others. The papillæ in the patches are almost if not quite obliterated, the epithelium is considerably altered, and there is an infiltration of round cells in the underlying tissues. The chief interest of this condition lies in the fact that very frequently epithelioma develops in a tongue so affected (see Fig. 563).

III.—INFECTIVE TUMOURS AND TUMOURS PROPER OF THE MOUTH.

Syphilis.—Various syphilitic lesions are met with in the mouth, ranging from slight inflammation to deep ulceration.

It is not uncommon to meet with a **Primary chancre** on the lip. In that case there is a prominent tumour which has, in more than one instance, been taken for an epithelioma. On microscopic examination the tumour is found to consist of immense aggregations of round cells which may be altogether beneath the epithelium.

The **Catarrh** which accompanies the **Secondary stage** is often very slight, but it may be accompanied by superficial ulceration of considerable extent. **Mucous patches, Flat condylomata,** or **Warts,** are particularly frequent in the mouth, and they often break down and form superficial ulcers, especially on the lower lip and at the angle of the mouth.

The deeper ulcers arise in connection with **Gummata,** which form in the substance of the mucous membrane, and may lead to very serious loss of substance. If healing occurs a cicatrix forms, but cicatrices sometimes occur without ulceration having taken place, the gumma itself giving place to a cicatrix. The gummata not infrequently have their seat deep in the substance of the tongue, and the resulting cicatrices, with or without ulceration, may produce very marked deformity of this organ.

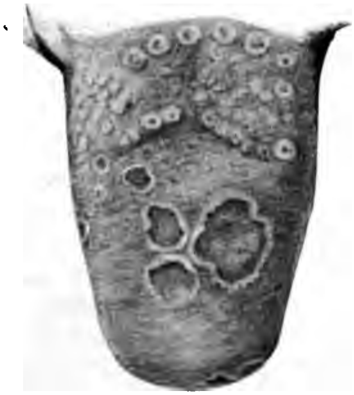
Fig. 564.—Wandering rash. From the tongue of an infant.

In young children the tongue occasionally shows circular patches somewhat resembling those of ringworm (see Fig. 564). These were regarded by Parrot as evidences of syphilis but without sufficient proof. The term *annulus migrans* or **Wandering rash** is applied to this condition on account of the striking manner in which these patches travel over the surface of the mucous membrane.

Tuberculosis is uncommon in the mouth. It may extend from the skin in **Lupus,** and in that case sometimes produces considerable ulceration. **Tuberculosis of the tongue** is the most common form of buccal tuberculosis (see Fig. 565). There may be a somewhat deep-seated infiltration, so that tubercles are present even amongst the muscles (see Figs. 566 and 64, p. 191). Interstitial inflammation may cause considerable induration of the tongue. Ulceration almost invariably occurs (see Fig. 565). There may also be considerable caseous masses in the substance of the tongue.

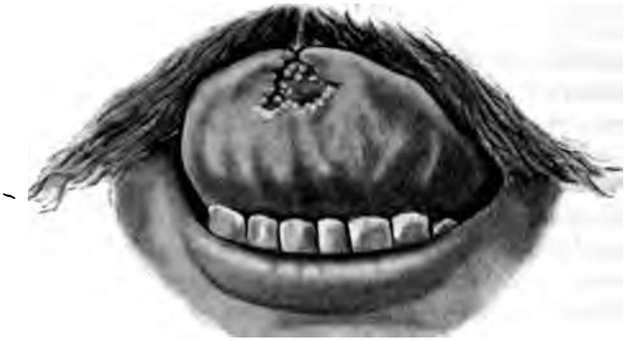

Fig. 565.—Tubercular ulcer of the tip of the tongue.

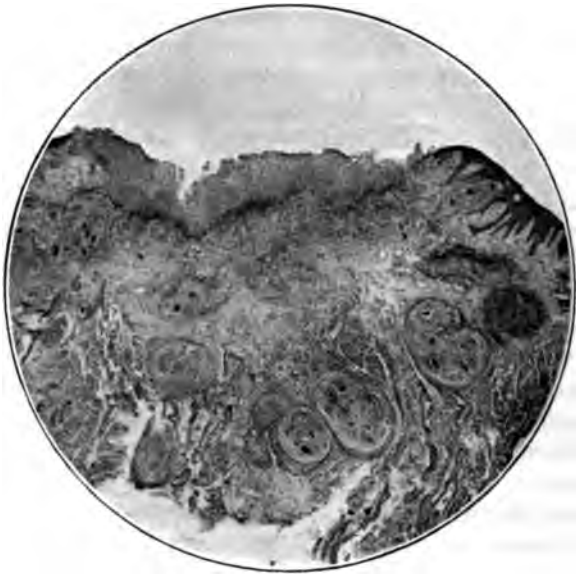

Fig. 566.—Tubercular ulcer of the tongue of a child. A large number of tubercles are shown amongst the muscles. × 15.

Leprosy also frequently affects the mucous membrane of the mouth, nd **Glanders** occasionally manifests itself here.

Tumours proper.—These are of somewhat frequent occurrence and onsiderable variety. We meet rarely with fibromas, lipomas, and nchondromas. Rather more common are **Glandular tumours** of the ps. These take origin in the mucous glands of the lips, and freuently become converted into mucous or colloid **Cysts**. They form rominent rounded tumours, sometimes as large as a hazel nut, and re readily enucleated.

Warts occur on the lips, especially at the edges. In that situation hey are mostly hard, while those on the proper mucous membrane re soft. Not infrequently the wart ulcerates, and, it is said, may give rigin to a cancerous tumour. Warty outgrowths also occur on the ongue. The papillæ of the tongue sometimes undergo great elongaion, especially their epithelial layers, and we may have a condition esembling **hairs** on the tongue, often associated with "**Black Tongue.**"

The Angioma is met with chiefly on the lips, usually in the form of he nævus. It occurs either as the cavernous or capillary angioma, and orms flat elevations or rounded prominent tumours. It occasionally ccurs on the tongue.

The **Lymphangioma** is a cavernous lymphatic tumour, which occurs hiefly in the tongue, and in some cases contributes to the formation f macroglossia. The whole tongue may be permeated with dilated mphatic vessels.

Macroglossia is a condition in which the tongue is greatly increased bulk, the enlargement being nearly always congenital. It is frequent **cretins**. Even at birth the tongue may be too large for the mouth nd project beyond the lips. Afterwards it may increase still more, nd, as the child grows, it may displace the alveolar processes considerbly. For the most part there is no hypertrophy here except of the terstitial connective tissue, but evidences of new-formation of uscular tissue have been observed. As a rule, the lymph spaces of he hypertrophied connective tissue are greatly enlarged, and there is ven a formation of cavernous tissue, the spaces of which are filled with ymph. In this way we may speak of **lymphangioma cavernosum** as aking part in the condition. It will be observed that the condition ere somewhat resembles that in elephantiasis, there being in both ases a great new-formation of succulent connective tissue with wide ymph spaces. The resemblance is further indicated in the fact that he lips frequently hypertrophy as well (*Macrocheilia*).

Sarcomas rarely develop in the mouth itself, although they are ccasionally met with in the tongue.

On the other hand, it is not uncommon to find a **Myeloid sarcoma** of the jaws, growing from the periosteum and projecting into the mouth. This is the commonest form of **Epulis**, a name given generally to tumours which arise from the alveolar processes of the jaws. They are mostly composed of spindle-cells, but nearly always contain **Giant cells**, and sometimes these are in large numbers. Osseous trabeculæ frequently pass into them from the bone. As these tumours grow they push the mucous membrane of the gums before them and so form red or brownish prominences of a rounded form, behind, in front of, or between the teeth. They are generally of dense consistence. The teeth are often considerably displaced by them as they grow, especially when they assume large dimensions, as sometimes happens.

Cancers of the mouth are nearly all **Flat-celled epitheliomas.** They are of very frequent occurrence on the lower lip and are also common in the tongue.

Epithelioma of the lip is almost confined to the male sex. This is frequently ascribed to the fact that in men the lips are more frequently exposed to irritation by smoking short pipes and in shaving. The tumour, which has almost always its seat on the lower lip, is in the form of a superficial infiltration which soon goes on to ulceration. There may thus be great destruction of the lip structures. The structure is that of the typical epithelioma (see Fig. 192, p. 357), of which this is the most frequent seat.

In the tongue the epithelioma usually forms at the edge, and it is often attributed to the irritation of the sharp edge of a carious tooth. There is here also usually a superficial ulcer, but the tumour generally penetrates deeply into the substance of the tongue. There may also be considerable irritation of the tongue and new-formation of connective tissue so that the structure may resemble that of a scirrhus. As the epithelium of the tongue does not become horny, we scarcely have the typical laminated capsules of the ordinary flat-celled epithelioma. Epithelioma, we have already seen, occurs frequently in leucomatous tongues (see Fig. 563).

Secondary epitheliomatous formations are liable to occur in the submaxillary lymphatic glands, and may extend to the glands of the neck.

Ranula is a name applied to cysts which form beneath the tongue. These mostly arise as retention-cysts from closure of Wharton's duct (duct of the submaxillary gland), or one of the ducts of the sublingual gland, but they may take origin in the mucous glands. Before the occurrence of the cyst there is usually some inflammation of the floor of the mouth very often connected with affections of the teeth. According to the observations of Recklinghausen referred to at p. 322, he cyst arises by dilatation of the duct, while the gland structure ersists and furnishes the material by the accumulation of which he cyst forms (see Fig. 159, p. 323).

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IV.—AFFECTIONS OF THE TEETH.

The hard part of the tooth consists of enamel, dentine, and cement. he **Enamel**, containing very little organic matter (only about 2 or 3 er cent.), is for the most part passive, and presents great mechanical esistance to destructive processes. In its original formation it is a uperadded structure, derived from the epithelium of the surface. The **entine**, consisting of tubules with a hard matrix, possesses a much arger proportion of organic matter (28 per cent.), and is much more irectly involved in morbid processes.. The **Cement**, which covers those arts of the tooth which are devoid of enamel, consists of true bone, nd is liable to changes of a similar nature to those of bone.

Turning to the soft parts, the **Pulp** fills the cavity of the tooth, which avity has in general the shape of the tooth. The pulp is a highly ascular tissue, and richly supplied with nerves whose filaments pass in art into the dentinal tubules. The pulp is so sensitive that in popular anguage it is called "the nerve." In the original formation of the tooth the dentine is produced by the structure which is afterwards represented by the pulp, and through life the latter retains to a considerable extent its formative power.

The tooth is fitted accurately into the alveolus by means of the cement on the one hand and the **Dental periosteum** or periodontal membrane on the other. This membrane, lying between the cement and the bone of the jaw, forms a kind of double periosteum, and is, from its position, very liable to the action of mechanical forces, being placed between two rigid structures, one of which (the tooth) is peculiarly exposed to mechanical interference. It is continuous at the apex of the root with the pulp, and at the neck with the mucous membrane of the gums on the one hand and the periosteum of the jaw on the other.

1. **Caries.**—This name is applied to a condition which is not analogous to caries of bone, except in so far as in both there is destruction of the dense calcified structure. Caries of bone is related to inflammatory processes, but caries of the teeth has no such origin. It consists of a softening, usually progressive, of the enamel and dentine, and their subsequent disintegration. The process appears to begin very commonly in places where the enamel shows normally rather deep furrows, and is therefore thinner and more easily destroyed than elsewhere. When the caries reaches the dentine it advances more freely, so that the enamel may to some extent be undermined. The lime salts are first absorbed, and then the organic basis is broken down. The caries advances in the direction of the dentinal tubules, as shown in Fig. 567.

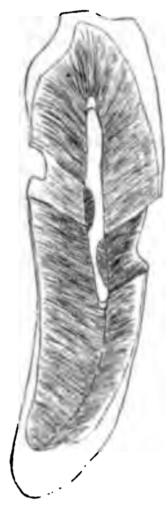

Fig. 567.—Section of tooth with caries. There are two cavities, one on each side, and in the pulp cavity a new-formation of secondary dentine. The secondary dentine is not exactly on the same level as the cavities, but at the extremities of the dentinal tubules leading from these. (After SALTER.)

Various views have been held as to the nature of the process. At one time it was regarded as inflammatory, but this view may be set aside, chiefly on the ground that a process exactly similar occurs in teeth which have been drawn and re-inserted, as well as in artificial teeth made of the ivory of the hippopotamus. The caries consists, in fact, of a gradual solution of the lime salts, and for this solution we must infer the existence of an acid. The secretion of the mouth is naturally alkaline, but in carious teeth an acid reaction has been detected. The acidity is often connected with derangements of the stomach, but it may have a more local origin, as when the secretion of the gums is abnormal, or perhaps when food is undergoing acid fermentation in contact with the teeth. It may be that before the teeth yield to an undue acidity they have already an abnormally weak power of resistance, and this may be related to personal peculiarities, inherited or otherwise.

At the advancing margin of the caries a widening of the dentinal tubes is visible, and in these widened tubes, as well as in the carious cavity, bacteria and **Leptothrix** threads are to be found. By some, especially by Klebs, the process has been ascribed to the action of these organisms.

2. **Inflammation** frequently follows on caries, and the pulp is usually involved. It is almost certainly attacked if the caries causes penetration into the pulp, but before this takes place there is frequently some inflammation which expresses itself in a new-formation of **Secondary dentine** inside the tooth around the point to which the caries is advancing (see Fig. 567). In this way the carious cavity may be shut off from the cavity of the pulp, and thus a more serious inflammation warded off. Very frequently, however, a more acute inflammation of the pulp occurs, with redness, swelling, great pain, not infrequently also with complete necrosis of the pulp, and, in consequence, of the whole tooth.

The inflammation often extends to structures around the tooth. The root-membrane or dental periosteum, which covers the root portion of the tooth, is the structure most directly attacked. This membrane is, as we have seen, intimately connected, towards the neck of the tooth, with the submucous tissue of the gums and the periosteum of the alveolar process of the jaw. Inflammations of these structures, especially of the gums, very frequently ensue, resulting in the well-known **Gum-Boil**, which often goes on to suppuration and abscess, forming the so-called **Parulis**. The abscess usually bursts into the mouth, but it may produce extensive swelling of the gum, and lead even to penetration outwards, resulting in a fistulous opening in the skin.

The result may be even more serious if the periosteum of the jaw becomes inflamed, resulting, it may be, in suppuration which is apt to be chronic. With the periostitis there is usually new-formation of bone, causing thickening of the jaw.

Inflammations of the root-membrane and periosteum of the jaw sometimes occur apart from caries, as a result, for instance, of poisoning with phosphorus or mercury, and in scurvy. In that case the inflammation is not limited to the neighbourhood of one tooth, but extends usually to a series.

3. **Conditions resulting from hereditary syphilis.**—In children who are the subjects of hereditary syphilis, the teeth show malformations first pointed out by Hutchinson. The teeth are narrow and pointed; the most obvious lesion being in the permanent front teeth of the upper jaw. The upper incisors are narrowed instead of being expanded towards the cutting edge, and the central ones have generally a crescentic notch which is very characteristic. This condition of the teeth is frequently associated with interstitial inflammation of the

cornea, and is ascribed by Hutchinson to a syphilitic inflammation of the gums during the formation of the teeth.

4. **Tumours connected with the teeth.**—The cement, which, it must be remembered, is composed of bony tissue, sometimes undergoes a hypertrophy to which the name **Exostosis or Osteoma** is often given. This is scarcely a true bony tumour, but originates rather in chronic inflammation of the cement, leading to a considerable new-formation of bony tissue. In this way are formed prominent tuberous outgrowths from the roots of the teeth, which may be localized to one part of the fang, or cover a considerable portion of it, or even the whole root portion of the tooth. In the latter case it is as if the root were enlarged by rough accretions on its surface. These so-called exostoses sometimes offer serious resistance to the extraction of the teeth.

Another form of tumour connected with the teeth is that which Virchow has called the **Odontoma**. This tumour arises in connection with teeth retained in the alveoli by faulty development. The tumours are composed of dentine and enamel, and are of small size and rare occurrence.

Cysts of the jaws have already been referred to (p. 663) as usually taking origin in connection with the teeth or their rudiments, and **Cancers** have occasionally a similar origin (p. 664).

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B.—The Soft Palate, Pharynx, and Tonsils.

Introduction.—The mucous membrane here differs from that of the mouth proper, chiefly in respect that in addition to the ordinary mucous glands there are numerous **Lymphatic follicles.** The distinction between these two is not always correctly appreciated. The mucous glands are racemose glands with proper ducts, opening on the surface of the mucous membrane. The follicular glands, as they are often called in rather a confusing way, are strictly comparable with the closed follicles of the intestine. In the pharynx, soft palate, and root of the tongue they occur in the form of isolated rounded masses of lymphatic tissue, like the solitary follicles of the intestine. In the tonsils we have aggregations of these follicles not unlike Peyer's tches. Their prominence in the tonsils causes the mucous membrane be thrown into folds, and so we have comparatively deep recesses, hich are sometimes called **Crypts**, in which secretions may accumu- te, especially if their depth is exaggerated by diseased conditions.

From their exposed position these parts are peculiarly prone to ritation from agents coming to them from without. The mucous embrane of the mouth seems peculiarly resistant to external irri- tions, but here, where there is the transition, as it were, from the ucous membrane exposed to external influences to that protected om them, these inflammatory manifestations occur with peculiar equency. Almost all the diseases we have to treat of here are forms f inflammation, and it is usual to describe these under the general esignation of Angina.

1. **Malformations.**—The **fistula colli congenita** (see p. 53) commonly opens into the pharynx, unless it be a blind external canal. Sometimes there is an internal fistula, which is incomplete externally. Sometimes also there is a cyst having this origin.

2. **Catarrhal angina**—In its acute form this constitutes the most rdinary sore throat, and results from "cold" especially at seasons f the year when sudden changes of temperature are prevalent, or ccurs as a local symptom of a general disease such as measles, scarlet ever, small-pox. It may be said regarding scarlet fever, small-pox, nd diphtheria that the throat affection in them begins with an acute atarrh, but that, especially in scarlet fever and diphtheria, it nearly lways goes on to phlegmonous inflammation. In the simple acute atarrh there is redness and swelling of the mucous membrane with mucous exudation which covers the surface and which has a tough onsistence. Sometimes vesicles form on the mucous membrane.

Chronic catarrh very frequently follows on the acute form, especially when there have been repeated attacks. The conditions are somewhat different in different cases, and rather complicated classifications have been introduced. As in other chronic inflammations there is here, for the most part, thickening of the mucous membrane, but in some cases the mucous membrane is indurated and atrophied. There may be a general hypertrophy of the superficial layers of the mucous membrane, and, as the blood-vessels remain congested, it is rather a succulent swelling. This constitutes what is called the **Relaxed throat**. The appearances are most pronounced in the case of the uvula, which becomes elongated, sometimes to a very marked extent. At other times the swelling is not so uniform, but with some general thickening there is an occasional localized prominence causing the mucous membrane to assume a granular appearance, hence the term **Granular pharyngitis**.

This form occurs mostly among clergymen, singers, actors, and others whose occupation requires them to use their voices for prolonged periods with a loud tone.

3. **Acute phlegmonous inflammation of the fauces.**—This frequently results in the formation of **Abscesses.** It is a condition of somewhat common occurrence. There is not merely a surface catarrh, but the mucous membrane and submucous tissue are involved in an acute inflammation of a very intense kind which usually goes on to suppuration. The disease very commonly begins on one side and frequently involves the tonsil, sometimes extending thence to the posterior wall of the pharynx. The swelling and redness are very great from hyperæmia and œdema of the whole structures, and the patient may have difficulty in opening the mouth. If it goes on to suppuration the pus often collects and forms an abscess which bursts into the throat. In some cases the acute inflammation extends downwards to the base of the epiglottis and the case becomes dangerous because of the possible supervention of œdema glottidis. It should be added that the name **Quinsy** is applied to this disease as well as to a more local inflammation of the tonsils alone.

We may infer that in this disease one of the pyogenic microbes finds access to the mucous membrane. It sometimes happens that the inflammation, after attacking one side, passes round and involves the other, and this looks like an irritant which propagates itself.

4. **Diphtheria.**—The changes which occur in this disease have already been referred to in considering its manifestations in the air passages (see p. 820). It usually begins in the fauces and has its centre there. There is in the fauces a fibrinous exudation usually associated with necrosis of the mucous membrane. There are other signs of inflammation, chiefly the presence of leucocytes infiltrating the mucous membrane and passing into the exudation. As a rule, there is necrosis of the mucous membrane, and this in all degrees till we come to the so-called gangrenous form. The resulting sloughs frequently look more serious than they are, but there may be considerable loss of substance, and ulcers of some depth and size may be left.

The position of the patches of exudation is very various. Sometimes they are mainly on the tonsils, sometimes on the soft palate and uvula. Extension to the posterior nares on the one hand, and to the larynx on the other, is very frequent, the latter, as we have seen, being particularly common.

5. **Acute tonsillitis. Quinsy.**—This inflammation of the tonsils is, as we have seen, occasionally a part of a general phlegmonous inflammation of the fauces. Occurring more independently it is

accompanied by considerable swelling, consisting of an inflammatory infiltration of the lymphatic follicles of the tonsils. Sometimes it goes on to suppuration, but rarely does so when the tonsils alone are affected. The swelling in many cases does not fully subside, and gives rise to a more or less permanent enlargement such as we have next to consider.

6. **Chronic tonsillitis. Hypertrophy of the tonsils.**—Certain persons, especially in childhood or youth, are prone to repeated subacute inflammations of the tonsils, and as these recur the tonsils acquire a permanent enlargement. This consists anatomically in a true hypertrophy of the lymphatic follicles, although there is sometimes also an increase of the interstitial connective tissue. The tonsils are rarely much indurated, the soft lymphatic tissue existing so abundantly as to make the structure as a whole somewhat soft. The enlargement is very variable, there being sometimes a rapid enlargement followed by a rapid subsidence.

The inflammation sometimes leaves behind deep pits and recesses in the tonsils. These may contain semi-solid plugs, consisting of the secretions of the mouth mixed with particles of food, microbes, and fungi. These sometimes become condensed into concretions or **calculi.** The contents of these exaggerated crypts, by reason of their decomposition, often irritate the tissue around.

The hypertrophy is not always the result of chronic inflammation. There are cases of congenital hypertrophy of the tonsils, and there are still more frequent cases of a gradual enlargement without any apparent attacks of inflammation. In this way the tonsils may acquire very large dimensions, reaching the size of a hen's egg on some occasions. These conditions also are met with chiefly in children.

In children it is common to have an enlargement of the closed lymphatic follicles of the pharynx, and especially of the naso-pharynx, having similar characters to the enlargement of the tonsils which is so frequent in children. To this condition the somewhat misleading term **Adenoid growths** is given.* The structure is that of lymphatic tissue, and the condition is an enlargement from chronic inflammation. In prolonged cases there may be an induration of the structures from connective-tissue formation.

7. **Syphilitic disease of the fauces.**—Here, as in the mouth, syphilis manifests itself in multifarious ways. A persistent **Catarrh** having the ordinary characters of subacute simple catarrh is very common. **Mucous patches** or **Condylomata** are tolerably frequent, especially on the pillars of the fauces and on the soft palate. In the tertiary stage with or without the formation of gummata, there may be **Ulceration**

of the mucous membrane. Not infrequently the ulceration extends very deeply and causes destruction of the uvula and palate. It may extend to the epiglottis and no further. It is frequently accompanied by considerable thickening and cicatricial contraction, so that it may lead to great deformity and sometimes to stenosis of the pharynx.

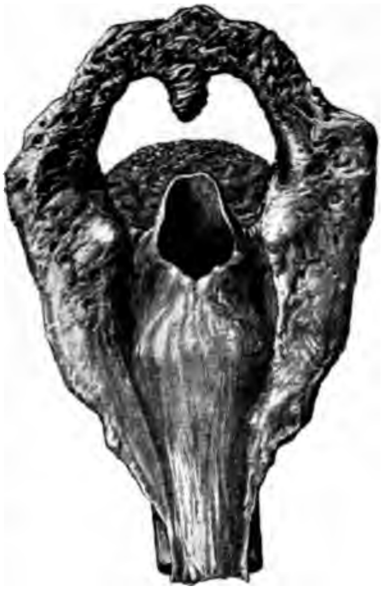

Fig. 568.—Extensive tuberculosis affecting pharynx, palate, uvula, etc.

8. **Tubercular ulcers.**—These are of comparatively rare occurrence. The disease is associated with phthisis pulmonalis, and is really due to an extension upwards of tubercular ulceration of the larynx. It occurs in the form of superficial ulcers, originally of a circular form (see Fig. 568).

9. The **Tumours of the fauces** are not so different from those of the mouth as to call for special remark, and they are altogether of much less frequent occurrence. We meet with papillary excrescences, cysts, sarcomas, and epitheliomas.

C.—The Œsophagus.

The diseases of this part of the alimentary canal are important from a practical point of view, chiefly because of the natural narrowness of the tube. The mucous membrane of the œsophagus is covered by a thick layer of stratified flat epithelium, and the mucous glands are comparatively few.

1. **Dilatation of the œsophagus.**—Of this somewhat frequent condition two forms may be distinguished.

(*a*) **General dilatation** of the tube is a result of obstruction at any part of its course. The obstruction is mostly low down in the œsophagus and may be even at the cardiac end of the stomach. With the dilatation in these cases there is usually considerable thickening of the muscular coat, although this is not always present. There is also sometimes a general dilatation without obstruction, probably due to diminution of contractility in the muscular coat.

(*b*) **Partial dilatation or Diverticulum** occurs in two principal forms, according as the force causing the dilatation is pressure from within the tube or traction from without.

The **Pulsion-diverticulum** arising by pressure from within may sometimes owe its origin to a slight congenital pouching of the tube. This may be due to an imperfect closure of the communication between the œsophagus and the trachea during fœtal life. If this closure be delayed, then the wall of the œsophagus may remain bulged out in front and from this beginning a larger diverticulum may arise.

More commonly, however, diverticula form on the posterior wall and usually at the junction of pharynx and œsophagus. It is probable that for the most part this form originates by a piece of hard food lodging in a fold of the mucous membrane, and being gradually pushed outwards, carrying the wall of the tube with it. As the sac enlarges, it hangs downwards with its mouth presenting upwards, and so it is always ready to receive the food in its passage downwards. It is probable that in most of these cases there is, to begin with, a separation of the fibres of the muscular coat of the œsophagus or pharynx, and the mucous membrane is pushed, as it were, through the muscular coat, which is thinnest at the junction of pharynx and œsophagus. If the sac is of any considerable size and filled with food, it will press on the part of the œsophagus situated below its mouth, and of itself produce an obstruction. In this way the food is prevented passing down the œsophagus and goes readily into the sac. We have therefore a continually increasing enlargement of the diverticulum which may reach the dimensions of a child's head or larger. It contains the remains of the decomposing food with mucus, sometimes in considerable masses. If the diverticulum is moderate in size its wall may still contain some muscular fibre, although the muscular coat is mostly absent except just at the neck.

The **Traction-diverticulum** arises by cicatricial contraction of structures adherent to the wall of the œsophagus. The contracting structure is mostly a lymphatic gland at the root of the lung, which has been affected with tuberculosis, usually in connection with phthisis pulmonalis. After healing of the tuberculosis, the gland has undergone cicatricial contraction, and by dragging on the wall of the œsophagus has produced a funnel-shaped pouch, the apex of which is usually composed of cicatricial tissue.

This form of diverticulum is peculiarly prone to **Perforation** at the apex if hard food impinges on it. This leads to acute inflammation in the neighbourhood, resulting in an abscess-like cavity, which may perforate the trachea or a bronchus, or the neighbouring pleura or pericardium. In the former case there will probably be gangrene of the lungs, and in the latter acute inflammation of the serous membrane.

2. **Obstruction of the œsophagus.**—This is sometimes **Congenital.** There may be a congenital deficiency in the middle part of the tube, a fibrous cord representing the occluded tube. In some cases the œsophagus below the occlusion opens into the trachea. Obstruction also arises as a consequence of pressure from without, by tumours, aneurysms, abscesses, but is still more frequent from disease in the tube itself. Ulcers of various kinds, by the cicatricial contraction incident to the process of healing, may induce obstruction, as, for example, ulcers from swallowing strong acids, syphilitic ulcers, etc. Still more frequent are obstructions from tumours of the œsophagus, and especially **Cancers** (see further on). As mentioned above, obstructions of the œsophagus frequently give rise to dilatation with hypertrophy of the muscular coat above the seat of constriction. Sometimes the dilatation is greater in one locality so that with a general dilatation there is a partial diverticulum.

3. **Inflammations of the œsophagus.**—The mucous membrane of the œsophagus is formed so as to resist the action of irritants, and unless the action be peculiarly strong we have not considerable inflammation. But when strong acids, or alkalies, or substances at a high temperature, are swallowed they may cause superficial necrosis and considerable inflammation of the mucous membrane. The small-pox eruption may extend into the œsophagus, producing inflammation.

Strong acids or alkalies, when swallowed, pass rapidly through the œsophagus, and so produce much less serious results than they do in the stomach. Acids produce whitish, yellowish, or brownish sloughs of the epithelium, sometimes penetrating the mucous membrane itself. Caustic alkalies, on the other hand, dissolve the epithelium, and produce a greyish gelatinous material which lies on the surface. If they penetrate the mucous membrane they reduce it to a soft brownish, half-diffluent substance. If recovery occur, there are at first ulcers with more or less violent inflammation, and afterwards healing with contraction of the ulcers and possibly considerable narrowing of the tube.

Small-pox pustules in the œsophagus are very similar to those in the mouth, and, like them, readily lose their epithelial covering and become converted into ulcers. They are accompanied by signs of inflammation of the mucous membrane generally.

A few cases of a peculiar inflammation of the œsophagus have been recorded in which the surface epithelium has been shed in the form of a consistent cast of a greater or lesser part of the tube. To this condition the name of **Œsophagitis dissecans superficialis** has been applied by Rosenberg.

Syphilis and **Tuberculosis** of the œsophagus are very rare. The latter has been found combined with cancer. **Antinomycosis** has also been observed.

Thrush occasionally, as we have seen, extends from the mouth downwards to the œsophagus (see Fig. 562, p. 930).

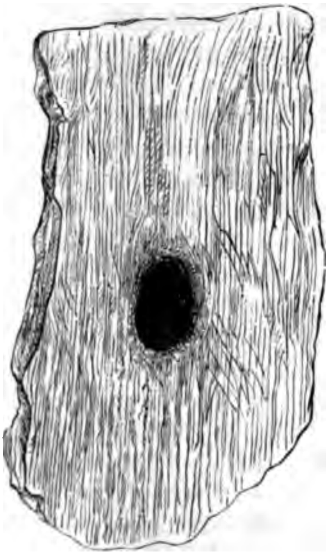

Fig. 569.—Perforating ulcer in the lower part of the œsophagus. The ulcer penetrated the main bronchus of the left lung.

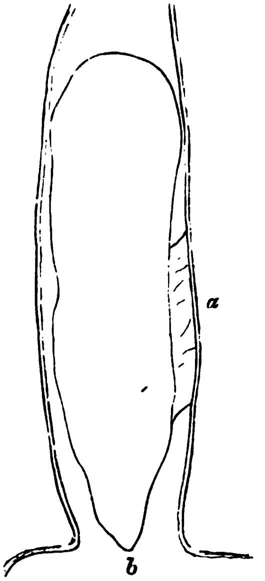

Fig. 570.—Polypoid myoma of the œsophagus in section, and semi-diagrammatic. The tumour was attached by a band-like pedicle *a*. It caused considerable distension of the œsophagus, and obstructed the tube. *b*, cardiac orifice of stomach. Half the natural size.

4. **Rupture and Perforation of the œsophagus.**—The œsophagus may be directly ruptured by hard and sharp bodies being swallowed with the food. The author observed a case in which a fish-bone cut through the œsophagus and entered the aorta.

A more frequent cause of perforation is disease of the wall. The **Traction-diverticulum** is, according to Zenker, the commonest cause of perforation. Next to that comes **Cancer** of the œsophagus, the actual perforation here being often produced by the sound.

Perforating ulcer sometimes occurs in the œsophagus, its causation being similar to that of the stomach (which see). Fig. 569 represents such an ulcer, which perforated into the left main bronchus, causing gangrene of the lung on account of food passing into the bronchi and lung alveoli. There have been cases in which the ulcer has penetrated the aorta.

5. **Tumours of the œsophagus.**—Simple tissue tumours are rare. We meet with **Lipomas** and **Fibromas**, and the author has described a case of **Myoma** (Fig. 570) in which a tumour, 4¾ inches long and 2 inches in thickness, was attached by a comparatively narrow neck, and produced death by obstructing the tube. Polypoid tumours having a fibrous structure and a similar form are met with.

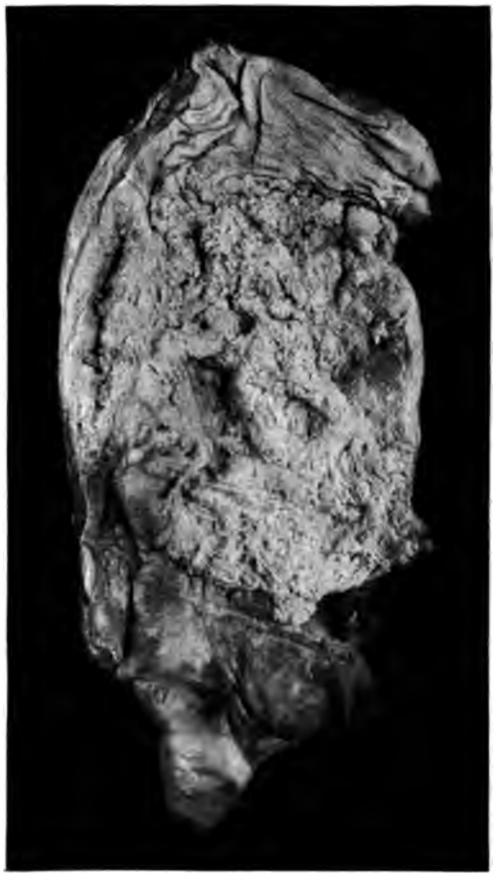

Fig. 571.—Squamous-celled epithelioma of œsophagus.

Cancer of the œsophagus is by far the most important form of tumour. The cancer is nearly always in the form of a flat-celled epithelioma, and in its histological details closely conforms to cancer of the lip. The masses of epithelial cells infiltrate the spaces in the underlying connective tissue, and the tumour also projects somewhat into the calibre of the tube. Here also there is a great tendency to ulceration, the mechanical action of the food in swallowing doubtless contributing to this result.

The tumour begins at a limited part of the mucous membrane, but it has a special tendency to extend round the tube in the form of a ring (Fig. 571). There has been considerable discussion as to the most common situation of the tumour, and the result of the comparison of various statistics seems to be that the most frequent seat is the lower third. Scarcely less frequent than this is the middle third, and especially the place corresponding with the bifurcation of the trachea. In the upper third epithelioma is comparatively infrequent.

This form of tumour, when it surrounds the tube, frequently leads to **Obstruction of the œsophagus**. On examining the œsophagus after death the seat of the tumour is often indicated externally by a narrowing of the tube, which is also more rigid here than elsewhere. The infiltration of the walls of the œsophagus, by irritating the connective tissue, causes a chronic inflammation with the usual new-formation of connective tissue, which contracts and narrows the tube. Besides this, the mere rigidity of the infiltrated tube, preventing its dilatation when the morsel is being swallowed, may produce a virtual obstruction at the point concerned. The projection of the tumour into the calibre is another element, which tells especially in the earlier periods. But as ulceration occurs, this projection of the tumour usually becomes inconsiderable, and there may even be a temporary relief to the stricture by partial destruction of the tumour. The ulceration

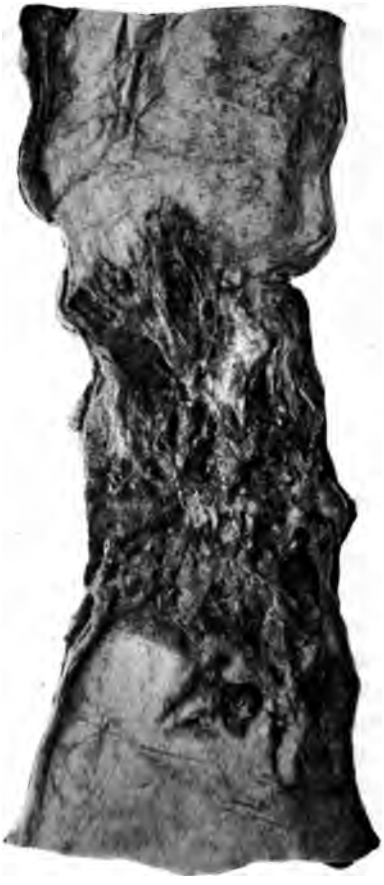
Fig. 572.—Lymphosarcoma of œsophagus.

itself, however, by inducing still further cicatricial contraction, may ultimately confirm the obstruction.

The tumour sometimes extends from the œsophagus to neighbouring lymphatic glands, or to surrounding structures, and so we may have the trachea, bronchi, or lungs involved in it. Sometimes it extends to the diaphragm, pericardium, vertebræ, etc. Tumours of the nature of **Lymphosarcoma**, originating in the lymphatic glands, may also extend to the œsophagus (see Fig. 572).

Literature.—KNOTT, Path. of the œsoph. (with references to literature), 1878; ZENKER, in Ziemssen's Encycl., vol. viii., 1878; KÖNIG, in Billroth und Luecke's Deut. Chirurg., xxxv., 1880; KLEBS (Diverticulum), Handb. d. path. Anat., i.; GODLEE and BUCKNALL, Med. Chir. Trans., Lond., 1901; BROSCH, Deut. Archiv. f. klin. Med., lxvii., 1900. *Œsophagitis dissecans*—ROSENBERG, Centralbl. f. allg. Path., No. 18, 1892; SELAVUNOS, Virch. Arch., cxxxiii., 1893, p. 250. *Tuberculosis*—WEICHSELBAUM, Wien. med. Woch., 1884; BECK, Prag. med. Woch., 1884; FLEXNER, Johns Hopkins Hosp. Bull., iv., 1893; CONE, ibid., viii., 1897. *Syphilis*—WEINLECHNER, Wien. med. Woch., 1880. *Perforating ulcer*—FINLAYSON, Glasg. Med. Jour., xix., 1883, p. 313; FLOWER, Med. Chir. Trans., xxxvi., 1853; HILTON, Path. Trans., vi., 1854; PART, ibid., viii.; QUINCKE, D. Arch. f. klin. Med., xxvi., 1879; KEHRER, ibid., xxxvi., 1885. *Tumours*—VIRCHOW, Geschwülste, iii.; ROSENBACH (Sarcoma), Berl. klin. Wochenschr., Sept. 20 and 27, 1875; COATS (Myoma), Glasg. Med. Jour., iv., 1872, p. 201; FAGGE (do.), Path. Trans., xxvi., 1875, p. 94; THOREL, Lubarsch und Ostertag, Ergebnisse, v., 1900.

D.—THE STOMACH.

Introduction.—In considering the diseases of the stomach, it is necessary to bear in mind certain points in regard to the structure and functions of the organ. The innumerable glands which exist in the mucous membrane are engaged in the formation of the **Gastric juice** for the purposes of digestion. The diseases of the stomach very readily interfere with the function of these glands, so that the secretion of gastric juice is insufficient in quantity or deteriorated in quality. In that case the **Food** is apt to lie in the stomach undigested, and it very commonly undergoes various forms of **Decomposition.** The products of decomposition acting on the mucous membrane still further interfere with the process of secretion, and by their irritative action keep up or induce a condition of catarrh of the stomach. Gases also develop in the process of decomposition, and these, by distending the organ, interfere with its proper peristaltic movements, and so hinder the passage of the food through the pylorus.

But it is not merely local diseases, such as inflammations and tumours, which interfere with the secretion of the gastric juice.

Changes characterized by **Cloudy swelling** and **Fatty degeneration** are met with in the glandular epithelium in numerous infective diseases—small-pox, typhus, septicæmia, etc.—as also in poisoning with phosphorus. In these cases the secretion of the gastric juice may be almost at a standstill, and if food be introduced it is apt to lie in the stomach; by its mere presence, and by the action of the products of decomposition, it may produce still further structural changes.

The forms of decomposition which the food undergoes when it lies undigested in the stomach are various, but the chief are those characterized by the development of **Acetic, Lactic,** and **Butyric acids.** The agents in these changes are microbes which are introduced in abundance with the food and propagate in the stomach, unless their multiplication is hindered by the action of the gastric juice. In the contents of the stomach, when at any time they are discharged during life, swarms of bacteria are found, and in addition there are nearly always proliferating spores of fungi and sometimes large numbers of sarcinæ.

It has been mentioned that the products of decomposition irritate the mucous membrane, but, in addition to that, microbes have been found in some cases to enter the glands and mucous membrane. In some of the cases the action of such microbes has produced little **Pustules** in the mucous membrane, or even larger prominences with necrosis and ulceration. It may be inferred that it is microbes of a special kind or in a peculiar state of activity which thus penetrate the mucous membrane. Stagnation of the food in the stomach and its decomposition will occur still more when, by stricture of the pylorus, there is a **Mechanical obstacle** to the passage from the stomach.

Besides the mere local effects induced by the products of decomposition, it is to be remembered that the mucous membrane of the stomach is actively engaged in **Absorption**, and that these products may to some extent be taken into the blood. It is probable that the headache and other nervous symptoms occurring in dyspepsia are in great measure due to the existence in the blood of small quantities of these poisonous agents and their action on the nervous system.

When the food remains in the stomach and accumulates there, it is usually got rid of after a time by **Vomiting**. This action is produced by irritation of a centre in the medulla oblongata, and the muscles employed are mainly those used in respiration, but in different combinations. The centre may be irritated directly, as by introducing apomorphine into the blood, or by disease of the brain itself. But in the case we are considering it is irritated by reflex stimulation, the stimulation taking origin in centripetal fibres in the stomach itself. The occurrence of vomiting is dependent on the nature and amount of the irritation applied and on the sensitiveness of the centre in the individual.

Post-mortem changes.—After death, any remains of food lying in the stomach are apt to decompose rapidly, especially as the gastric juice in most cases is not secreted in the normal way up to the period of death, and so the decomposition is not interfered with. The decomposing juices therefore act readily on the mucous membrane, and the decomposition may even extend to the latter. The principal changes produced are **Alterations in colour**, resulting from chemical changes in the colouring matter of the blood. This may diffuse out of the blood-vessels and stain the mucous membrane of a reddish hue, the colour being specially pronounced in the neighbourhood of the larger vessels. There is often a greenish colour developed by the decomposition of the blood. Later, the colour may be almost black or slaty, but in many cases this deep colour is not altogether a post-mortem change; it depends in part on a true pigmentation from chronic catarrh of the mucous membrane.

Softening of the stomach or Gastromalacia is also a post-mortem change. It is really a digestion of the coats of the stomach by the gastric juice. As a rule, in persons near death, the gastric juice is not secreted normally, but if the person die while the secretion of gastric juice is still active, then the latter may, by a process of **Digestion**, act on the coats of the stomach. This condition occurs mostly in persons who die suddenly, especially if the body is kept in a warm place, and it is more frequent in children than in adults. In the slightest degree, the mucous membrane alone is softened, and it can be removed by the finger as a soft paste from the surface of the muscular coat. Penetrating deeper, the muscular coat and even the serous coat may be half liquefied, so that on handling the stomach it may be perforated. The stomach may even **Rupture** in the body, and the contents pass outwards, producing softening in neighbouring parts. In some cases the diaphragm has been softened in this way, and part of the stomach contents have passed into the pleural cavity.

These various changes occur in those parts of the stomach where the contents have been lying after death. This is generally the neighbourhood of the fundus. As the contents are usually fluid, it is often seen that the changes stop short at a definite level and the unaltered mucous membrane is abruptly demarcated from the altered part. The pyloric portion of the stomach, as it usually lies highest, is least frequently affected, and this is important, as that part of the stomach is the most frequent seat of disease.

It must be borne in mind that the pathological changes met with in the stomach are very often obscured by the occurrence of these post-mortem changes.

Literature.—Leube, in Ziemssen's Encycl., vii., 1877; Kussmaul, D. Arch. für klin. Med., vi.; Brunton, Disorders of digestion, 1886. *Digestion of stomach*—Hunter, Phil. trans., 1772, and Works by Palmer, iv., 116; Burns, Med. and Surg. Jour., 1810; Bamberger, Krankh. d. chylop. Syst., 1855; Virchow, Wurzb. Verhandl., 1850; Reeves, Softening of stom. in children and adults, 1867; Pawlow, Die Arbeit d. Verdauungsdrüsen (Transl.).

I.—MALFORMATIONS AND CONTRACTIONS OF THE STOMACH.

1. **Congenital malformations.**—There may be abnormal smallness ither with or without other more general malformations. Sometimes n **Hour-glass form** occurs, the middle part of the stomach being contracted. This malformation may also be acquired by cicatricial contraction.

Atresia and stenosis of the pylorus are met with as congenital onditions. **Atresia** or complete occlusion occurs in the form either f a simple diaphragm between the stomach and duodenum (similar iaphragms may occur at other parts of the stomach), or as a more omplete separation, there being only a cord uniting the stomach and uodenum. **Congenital stenosis** of the pylorus is alleged to be of requent occurrence. According to Maier there are two forms, a funnel-haped and ring-shaped. In the former the pyloric portion of the tomach is converted chiefly by hypertrophy of the muscular coat, into a somewhat rigid funnel, whose apex projects into the loose duodenum. The condition is compared to that of the normal cervix uteri in its relation to the loose vagina. Tilger describes a case in which the stenosis extended to the first part of the duodenum. In the ring-shaped form here is an abrupt narrow projecting ring, formed by localized thickening of the muscular coat. The congenital stenosis is often associated with fixation of the pylorus due to a dense and thick hepatico-duodenal gament. Congenital stenosis like the acquired forms is followed y dilatation of the stomach sometimes associated with hypertrophy of the muscular coat. Care is required in diagnosing congenital stenosis, as various states of contraction of the muscular coat in the pyloric region may simulate it, and it may also be simulated by thickening due to chronic catarrh.

2. **Contractions of the stomach** may be general or local. A **General ontraction** is produced when the stomach is long deprived of food. This is most directly produced by obstruction of the œsophagus or ardiac orifice, but also occurs when, for any other reason, food is not aken. There is also a general shrinking sometimes as a consequence of scirrhous cancer, and a similar shrinking may be produced by perionitis which has led to thickening and contraction of the peritoneum generally.

Partial contractions are usually the result of cicatrization of ulcers. As these are mostly on the lesser curvature, the two orifices may be drawn close together. Sometimes an hour-glass contraction may be produced in this way. There is also occasionally an hour-glass contraction visible post mortem, which depends merely on an irregular contraction of the muscular coat and is of no special significance. Cancer of the stomach may produce partial contraction. It is to be remarked, however, that simple ulcers of the stomach mostly heal without considerable contraction, the cicatrices being quite flat.

Literature.—Widerhofer, Gerhardt's Handb. der Kinderkrankh., iv., 1880; Landerer, Angeb. Stenose des Pylorus, Tübingen, 1879; Maier, Virch. Arch., cii., 1885; Tilger, ibid., cxxxiii., 1893; Carrington (Hour-glass contr.), Path. Trans., xxxiii., 1882; Hudson, ibid., xxxviii., 1887; J. H. Nicoll (with literature), Congenital Stenosis of Pylorus, Trans. Med. Chir. Soc., Glas., iii., 1902.

II.—DILATATION AND HYPERTROPHY OF THE STOMACH.

These conditions mostly result from obstruction to the passage of food through the pylorus from contraction of that orifice. A simple weakness of the muscular coat may also allow of passive distension. **Obstruction of the pylorus**, causing an accumulation of the contents, leads in the first instance to a **simple distension** of the organ, which tells chiefly on the parts which are free to swell out. The lesser curvature is fixed by its attachments, and it usually retains nearly its normal position except that its middle part is somewhat dragged downwards. The greater curvature, on the other hand, is carried downwards, and the stomach may apparently fill the entire abdomen, reaching as far as the symphysis pubis. Sometimes the pylorus is depressed and the duodenum correspondingly displaced.

The general result of obstruction of an orifice is compensatory **hypertrophy of the muscular coat** of the viscus, such as frequently develops in the heart and urinary bladder. But the muscular coat of the stomach has a somewhat different function to that of the heart or bladder. In the latter there is a simultaneous contraction of the entire muscle with a view to the emptying of the viscus. In the stomach, however, the contraction is vermicular, and its object is as much to move the contents about inside the stomach as to empty them into the duodenum. In the actual propulsion of the contents into the duodenum it is the pyloric portion of the stomach that is engaged, and here also the material is carried forward by a vermicular movement. Hence the hypertrophy of the muscular coat in obstruction of the pylorus does not occur uniformly in the stomach, but **localizes itself in the pyloric portion**, sometimes even with a special thickening just at the orifice, forming a **tight Sphincter**. In these cases, when the wall of the stomach is divided, the progressive thickening of the rigid muscular coat can often be distinguished as the pylorus is approached. As the muscle of the stomach is in bundles, hypertrophy produces an exaggeration of these, and on section they are frequently very prominent, especially as the connective tissue septa between them are also hypertrophied. The alternating bundles, as seen on section, have been compared with the leaves of a fan.

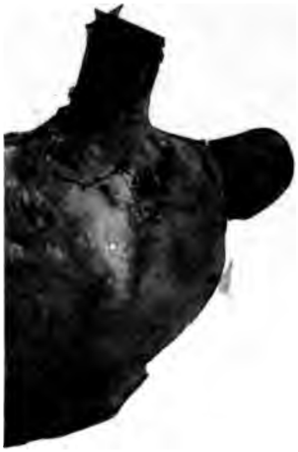

Fig. 573.—Gastric diverticulum near the greater curvature.

Besides general dilatation, which is of common occurrence, a localized dilatation or **Diverticulum** is met with, but is exceedingly rare. Tilger describes a case of Traction-diverticulum (see under Œsophagus) in which the traction from without of an adherent and displaced gall-bladder had been the cause. Pulsion-diverticula are equally rare. In the case illustrated by Fig. 573, the diverticulum was essentially a hernia of the mucous membrane through the muscular coat and was thus comparable with the much more common "false diverticula" of the intestine.

Literature.—PENZOLDT, Magenerweiterung, 1875; LEUBE, in Ziemssen's Encycl., vii., 1877; CAMPBELL THOMSON, Acute dilatation of stomach, 1902; TILGER, Virch. Arch., cxxxiii., p. 201, 1893; JOSHUA FERGUSON (Diverticula), Glas. Med. Journ., 1897 (with references); HAHN, Deutsch. Arch. f. klin. Med., lxiii., 359, 1900.

III.—INFLAMMATIONS OF THE STOMACH. GASTRITIS.

Acute inflammations may be produced by the action of irritant substances. **Phlegmonous inflammation** is rare in the stomach as compared with the frequency of phlegmonous angina of the fauces, or dysenteric inflammation of the intestine. A localized and a diffuse form have been described, the latter occupying the stomach wall extensively, and causing great thickening (see Fig. 574). There is great swelling and redness of the mucous membrane, terminating in purulent infiltration of the wall of the stomach, chiefly of the submucous tissue. Sometimes multiple abscesses form in the wall of the stomach and burst into its cavity. It has been found in some cases to be related to an invasion of streptococci, in this and other respects resembling erysipelas. It may take origin in an ulcer or ulcerating cancer, but frequently the origin of the infection is obscure.

Catarrh of the stomach, on the other hand, is a condition of very frequent occurrence and is met with in the acute and chronic forms.

Acute catarrh.—This is an acute inflammation usually induced for the most part by the direct action of irritants on the mucous membrane, mainly by the use of irritating foods or drinks. When food remains in the stomach undigested it undergoes decomposition, and the irritating products may induce an acute catarrh. But the mere prolonged stay of food in the stomach probably induces it, as when the secretion of the gastric juice and the peristaltic action necessary to the process of digestion are interfered with.

It is seldom that the stomach can be examined after death in this condition, but from the observations of Beaumont on his patient with a gastric fistula, as well as from experiments on animals, the appearances of the mucous membrane have been tolerably well made out. There is intense redness with swelling of the mucous membrane, which is covered by a layer of mucus or muco-pus, sometimes slightly mixed with blood. The appearances are most marked towards the pylorus, and sometimes confined to that region.

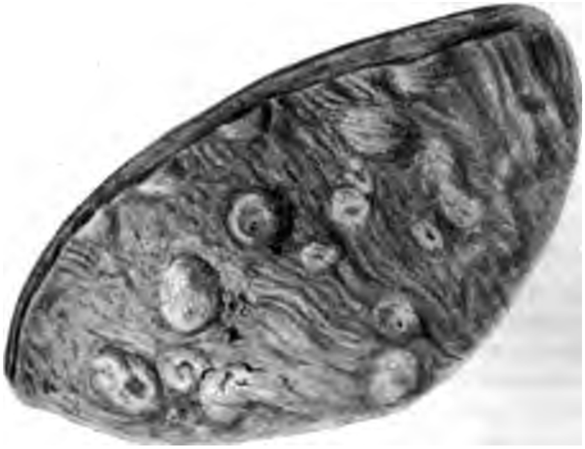

Fig. 574.—Phlegmonous gastritis. A portion of the infiltrated wall of the stomach is shown. At several places abscesses opening on the surface are seen.

Under the microscope the blood-vessels in the mucous membrane, and especially in the sub-mucous tissue, are found enormously distended and the epithelial cells, both those of the surface and of the glands, enlarged and granular.

Chronic catarrh.—This often remains after one or more attacks of the acute form. It is also present in cases of passive hyperæmia of the stomach, which so frequently occurs in consequence of diseases of the heart and liver. Cancer of the stomach is also accompanied by chronic catarrh in most cases.

If the catarrh is prolonged there usually occurs a considerable new-formation of connective tissue, as in other chronic inflammations. There is thus a thickening which affects the mucosa, submucosa, and muscular coat, and causes the surface of the mucous membrane to assume an irregularly folded or warty appearance, which has given rise to the designation *état mamelonné*. The mucous membrane also presents, in many cases, dark spots or a general deep slaty colour, from the presence of pigment granules in the tissue. The pigment is derived from the blood, and indicates the occurrence of hæmorrhages, probably by diapedesis. The increase of the connective tissue produces **Atrophy of the glands**, which are also considerably distorted.

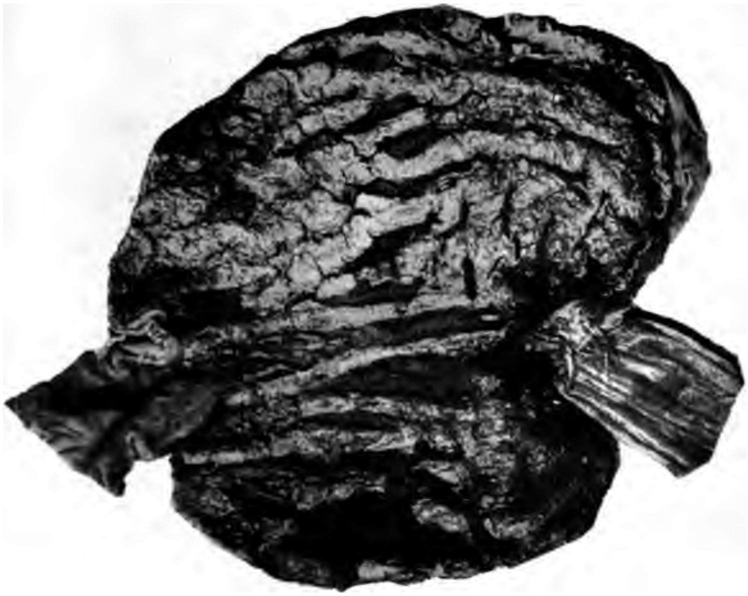

Fig. 575.—The stomach in carbolic acid poisoning.

It sometimes happens that the increase of connective tissue is specially great, and the wall of the stomach may be converted into a thick, hard, resistant structure. As all these processes occur mainly in the pyloric portion of the stomach, considerable **Narrowing of the orifice** may result. The rigidity of the wall and the narrowing of the orifice induce more forcible muscular contractions, and the muscular coat therefore hypertrophies. The thickened and indurated condition may closely resemble scirrhus of the stomach, especially as the muscular coat is often hypertrophied in that disease also.

Occasionally **Mucous polypi** develop in connection with chronic catarrh, and these may develop into mucous cysts.

Action of corrosives, caustics, and poisons.—Strong acids and alkalies acting on the stomach wall cause necrosis to a greater or less extent. As already noted the œsophagus is often but slightly involved. The intestine, on the other hand, is frequently affected, sometimes as far down as the ileo-cæcal valve. The intensity of the action depends largely on the concentration of the acid or alkali. Sometimes the whole thickness of the stomach is dissolved, and, the contents escaping, the action extends to the abdominal organs. The affected parts show various colours, acids generally producing a dark colour, while alkalies lead to a more tawny appearance.

If the patient survive, the sloughs will be discharged, and there is subsequently cicatricial contraction, leading sometimes to serious deformity and stenosis of the stomach.

Carbolic acid produces a dry, stiff condition of the mucous membrane. The altered epithelium may have a pearly white appearance (see Fig. 575). This condition may also extend to the intestine. (See cases in Western Infirmary Museum, Glasgow.)

Arsenic does not produce necrosis, but an irritation, evidenced by hyperæmia, and sometimes by ulceration. Decomposition is prevented by the presence of considerable quantities of arsenic.

Literature.—ABERCROMBIE, Researches on dis. of stomach, etc., 3rd ed., 1837; LEUBE, loc. cit.; FENWICK, Morbid states of stom., 1868, Atrophy of stom., 1880; HABERSHON, Observations on dis. of abdom., 3rd ed., 1878; FOX, in Reynold's Syst. of med., 1868; BEAUMONT, Expers. and observations on gastric juice, etc., 1833; SILCOCK (Phlegmonous infl.), Path. Trans., xxxiv., 1883; LEITH, Edin. Hosp. Reports, iv., 1896 (with literature).

IV.—THE SIMPLE PERFORATING ULCER.

This peculiar form of ulcer is met with only in the stomach, first part of the duodenum, and lower part of the œsophagus. The duodenum is not an infrequent seat, the œsophagus a more unusual one. It is also called the **Round**, the **Chronic**, and the **Perforating ulcer**. It is clear from the localities in which it occurs that its peculiarities are due to the action of the gastric juice.

The ulcer is usually round or oval in shape, and presents the appearance as if a conical piece of the wall of the stomach had been punched out from within, its edges being perfectly defined without any considerable thickening of the neighbouring mucous membrane, and the floor of the ulcer perfectly clean (see Fig. 576). The superficial extent and depth of the ulcer vary. The commonest size is about that of a shilling, but this may be considerably exceeded, and Cruveilhier has described an ulcer which was $6\frac{1}{2}$ inches long and $3\frac{1}{2}$ inches broad. In the smaller ulcers the floor is formed of the coats of the stomach, probably with some new-formed connective tissue. In the larger and deeper ones the tissue of neighbouring organs may be exposed, such as that of the pancreas or liver. The floor of the ulcer does not present any of the usual appearances of a granulating wound, but is clean and smooth, the actual tissue of the part being exposed, perhaps indurated from new-formation of connective tissue.

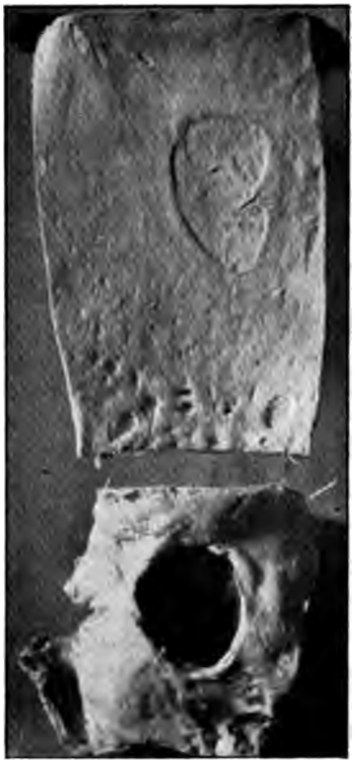

Fig. 576.—Perforating ulcers of the stomach open and healed, from the same case. In the upper piece of tissue is a flat slightly depressed cicatrix and some smaller ones near the lower border. The lower piece shows a deeply excavated ulcer, which had caused death by perforation into the peritoneum.

The situation of the ulcer is mostly in the neighbourhood of the lesser curvature, and nearer the pyloric than the cardiac orifice. It is more frequent on the posterior than the anterior wall. Although often single, it is common to find more than one ulcer present in the same case.

The ulcer presents a tendency to penetrate more and more deeply, from which circumstance it is named the Perforating ulcer. It does not appear to extend circumferentially to any considerable degree; it is probable indeed that at the very first the ulcer assumes its full superficial dimensions. Eating into the wall of the stomach, it may penetrate through the entire coats, and sundry accidents are liable to ensue.

One of the commonest of these accidents is **Hæmorrhage.** The ulcer penetrates one or more vessels at its base. The vessels may be small and the hæmorrhage not very considerable, but sometimes a larger artery is laid open, and a serious, even a fatal hæmorrhage results. From the commoner situations of the ulcers the arteries most frequently penetrated are these—the coronary artery or one of its branches, the gastro-epiploic, the pancreatic, and the splenic. Sometimes the open mouth of the vessel can be seen, after death, in the floor of the ulcer (see Fig. 577).

Perforation is another result of the penetration of the ulcer. For the most part, by the time the ulcer has eaten through the wall of the stomach, the latter has already acquired adhesion to some neighbouring structure, and so actual rupture of the stomach and escape of its contents into the peritoneal cavity are not common. The adhesion may be to the liver or pancreas, or, more rarely, to the spleen, diaphragm, colon, or abdominal wall. By the extension of the ulcer these structures may be eaten into and their tissue exposed. The tissue when first exposed has its normal appearance, but it usually becomes condensed and cicatricial. Sometimes the irritation of the gastric juice produces suppuration and the formation of an **Abscess**, especially in the case of penetration into the liver.

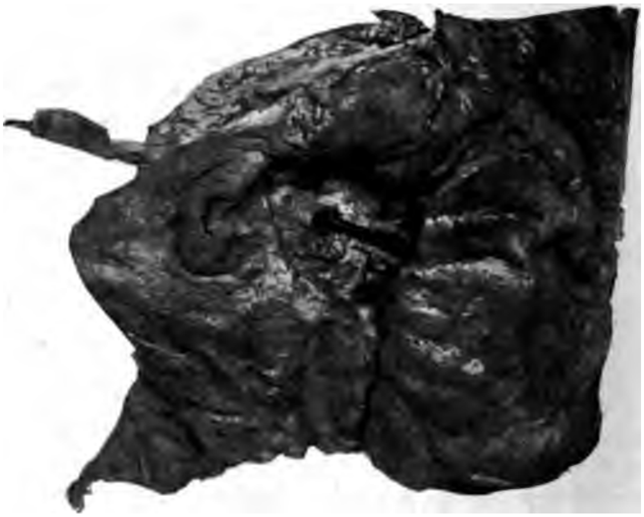

Fig. 577.—Perforating ulcer of the duodenum opening into the gastro-epiploic artery and resulting in fatal hæmorrhage. The ulcer, which is quadrilateral in form, is situated immediately beyond the pylorus. The floor is formed in part by the pancreas. A piece of whale-bone has been passed through the artery.

Rupture of the stomach results if perforation occur without previous adhesion of the wall. This will happen most readily where the wall of the stomach is liable to shift about during the regular peristaltic movements, and also where there is no solid viscus to which it may readily adhere. Both these conditions are fulfilled in the case of ulcers of the anterior wall, and so it happens that rupture most frequently occurs in this situation. The ulcers which lead to perforation are quently very small, and the aperture in the serous coat may be as ge as the ulcer itself. The result of the rupture is acute peritonitis, ich is generally fatal.

he ulcer, when situated at or near the pylorus, may lead to partial **Obstruction the pylorus**. This may be due to distortion of the parts and folding of the ous membrane from shrinking of the ulcer. It will follow most readily in ers of the duodenum immediately beyond the sphincter. This situation is uncommon, and the ulcer not infrequently partly involves the edge of the orus. In a case observed by the author the symptoms during life and even appearances after death strongly suggested cancer of the pylorus.

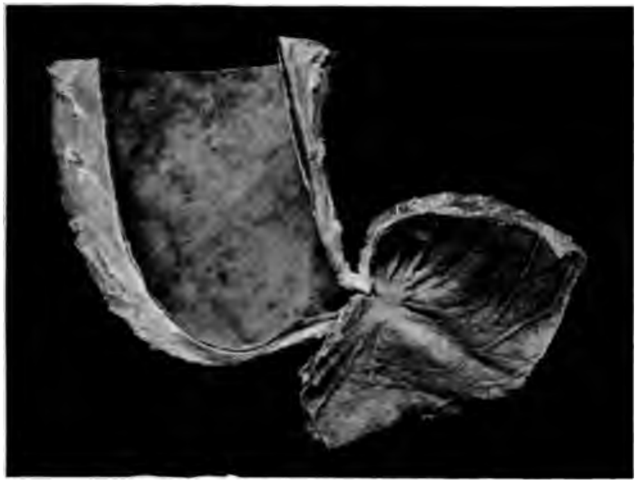

Fig. 578.—Stellate cicatrix of a duodenal ulcer with extreme stenosis near the pylorus.

Healing of the perforating ulcer is by no means an unusual occur- nce. In the experiments to be referred to presently, in which ulcers re produced artificially in animals, they healed very readily. In n also they are frequently recovered from, and we often meet with atrices in the stomach. The cicatrices are usually flat, as in Fig. 6, and there may even be no very obvious cicatrix at all. The thor met with a case in which three weeks after a very severe morrhage, presumably from an ulcer of the stomach, only an obscure atrix could be found. In some cases considerable contraction occurs healing. In the case of ulcers near the pyloric ring, this may lead marked stenosis (see Fig. 578). In order that healing may result, acrid condition of the gastric juice, which seems to be the chief nt in their causation, must be corrected.

The mode of origin of these ulcers is a matter of some difficulty. It is obvious, from the shape and appearance of the ulcer, that it has arisen by the necrosis and subsequent digestion of a piece of the wall of the stomach. The funnel-shaped outline of the ulcer suggested to Virchow that the necrosis occurred by obstruction or interference with an arterial branch, and he observed as confirmatory of this that the ulcers most frequently had their seat at the point of entrance of arterial branches into the wall of the stomach. The experiments of Panum and Cohnheim confirm this view in so far as they show that ulcers may be produced by embolism of the arteries of the stomach. The perforating ulcer, however, is not met with specially in cases of embolism or thrombosis of the arteries of the stomach, but in the immense majority of instances in cases where no such disturbance of the circulation exists. It has been suggested again that a venous hyperæmia, by causing stagnation and even hæmorrhage (see afterwards) in defined areas of the mucous membrane, may produce such weakening of the tissue as to induce necrosis and digestion of it.

In most cases of gastric ulcer there is serious and usually prolonged **Dyspepsia**, and the persons are frequently anæmic. Some abnormal condition of the gastric juice, by virtue of which it is peculiarly irritating to the mucous membrane, seems to be an essential factor, while a weakened condition of the mucous membrane is also of consequence. In most cases the gastric juice is abnormally acid, and it has been thought that by neutralizing the natural alkalinity of the tissues it may lead to their necrosis.

On the whole it seems probable that an acrid gastric juice, taking advantage of any accidental stagnation in a defined area of the mucous membrane, may lead to its necrosis and the formation of the ulcer.

The frequency of ulcer of the stomach may be judged of from the fact that, according to the results of post-mortem examinations, it is said that there are ulcers or cicatrices in about one in twenty of the cases examined after death.

Literature.—BAILLIE, Morb. Anat., 3rd ed., 1812; BRINTON, Ulcer of stom., 1857; VIRCHOW, Arch., v.; MÜLLER, Geschwür des Magens, 1860; PANUM, Virch. Arch., xxv.; COHNHEIM, Allg. Path., ii.; KLEBS, Handb., i.; LEUBE, in Ziemssen's Encycl., loc. cit.; HAUSER, Das Magengeschwür, sein Vernarbungsproc., 1883; FENWICK, Jour. of Path. and Bact., vol. i., 1893, p. 417; LEITH, Edin. Hosp. Rep., vol. ii.

V.—HYPERÆMIA AND HÆMORRHAGE.

Passive hyperæmia of the stomach is of very frequent occurrence, being brought about not only in that large class of cases in which here is a general venous engorgement, but also in those in which a calized lesion of the liver obstructs the portal circulation. The ucous membrane is generally reddened in such cases, and there is sually some catarrh. There are commonly also hæmorrhagic erosions isible (see below).

Severe vomiting also leads to passive hyperæmia, apparently by he spasmodic contraction of the muscular coat obstructing the veins. ere also there may be considerable hæmorrhage.

Hæmorrhage occurs under a considerable variety of circumstances. lcers, whether simple or cancerous, frequently cause it. It may esult, as just mentioned, from passive hyperæmia, and it occurs much nore rarely in scurvy, purpura, yellow fever, and typhus.

In the case of ulcers there may be large hæmorrhages from the upture of considerable vessels. In passive hyperæmia there is rather leakage from the superficial vessels of the mucous membrane, these eing least supported, and the blood passes chiefly into the cavity of he stomach. At the same time there is some infiltration of the ucous membrane in its superficial layers, and these parts being njured by the blood may be digested by the gastric juice. In this ay arise small flat superficial ulcers, the so-called **Hæmorrhagic rosions**. These are generally present in considerable numbers, chiefly n the pyloric region. In the erosions there may be still some remains f blackened blood, and alongside them there are little areas of mucous embrane infiltrated with blood. In these cases also the mucous embrane often presents a general redness from the passive hyperæmia, nd may be thickened by catarrh.

The blood, in whatever way arising, is generally mixed with the contents of the stomach, and blackened by the gastric juice. If the hæmorrhage be very severe, as from an ulcer perforating a considerable artery, the blood may be vomited nearly in the fresh state, but usually it is tarry or like coffee-grounds. The altered blood will also pass into the duodenum and onwards.

Blood sometimes accumulates in the stomach when it has a different source, as when an aneurysm ruptures into the pharynx or œsophagus.

VI.—TUBERCULOSIS AND SYPHILIS OF THE STOMACH.

Tubercular ulcers are rare in the stomach, although very frequent in the intestine. They sometimes occur in cases of advanced phthisis pulmonalis, and are more common in children than in adults. The ulcers are more superficial than those in the intestine (see Fig. 579), resembling rather those of the urinary bladder, although deeper. They have overhanging edges and granular floors.

The rarity of tubercular ulcers in the stomach as compared with the intestine may be due to two circumstances. In the first place the gastric juice will inhibit the tubercle bacilli in their passage through the stomach, and, in the second place, the stomach is defective in closed follicles, which in the intestine are the primary seats of the tuberculosis. This latter fact may also account for the smaller size and more superficial character of the ulcers.

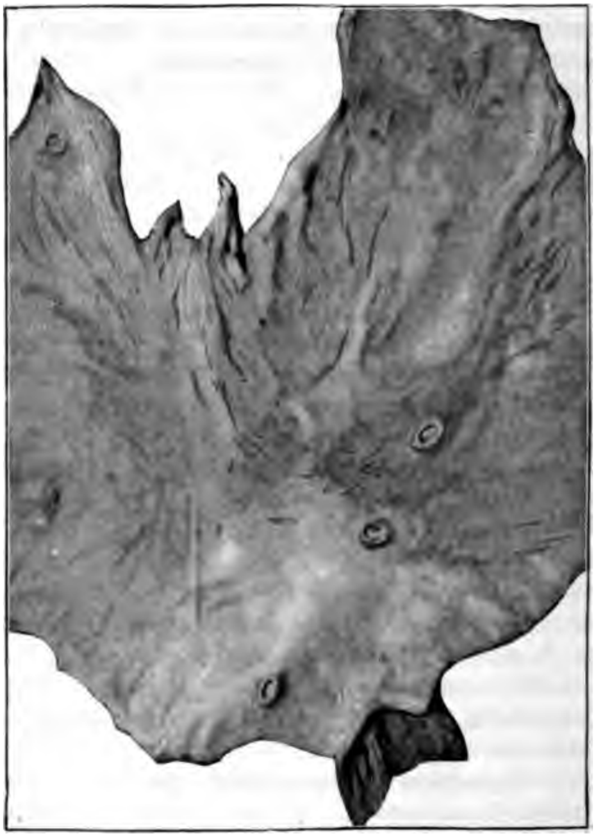

Fig. 579.—Tubercular ulcers in the stomach of a child.

Syphilis is also excessively rare in the stomach, but Birch-Hirschfeld records two cases in his *Lehrbuch*, apparently of congenital origin.

Literature.—Coats, Glasg. Med. Jour., xxvi., 1886, p. 53; Kühl, Ueber tuberculöse Magengeschwüre, 1889; Habershon, Path. Trans., 1894, p. 73; Birch-Hirschfeld, Lehrb., 3rd ed., 1887, ii., 538; Blumer, Albany Med. Annals, 1898.

VII.—TUMOURS OF THE STOMACH.

Cancer.—This form of tumour is of much practical importance, and is of exceedingly frequent occurrence. From the statistics of a nsiderable number of observers it appears that cancer occurs more equently in the stomach than in any other situation in the body, e uterus being the next most frequent site.

The great frequency of cancer in the stomach is probably related to the fact at the epithelial structures of this organ are more exposed to various irritations an those of any other part of the body. Not only have we varieties of irritating ods, but the foods are liable, as we have seen, to decomposition, the products of ich produce irritation. In cases of cancer there is very commonly a history of olonged dyspepsia, perhaps from youth.

In this relation the simple ulcer may be again referred to. There have been ses observed in which cancer seemed to originate in the simple ulcer; but the nple ulcer is a disease mostly of youth, whereas cancer is a disease of middle e, the average age being fifty years. It is almost as if similar causes produced e simple ulcer in youth, and cancer in middle life.

In its **Structure and Mode of growth,** cancer of the stomach conrms to cancer elsewhere. It consists of epithelial masses contained a stroma.

The epithelium originates from the epithelium of the mucous memane or its glands, and sometimes it retains to a large extent the andular characters. In growing, the cancerous tissue first infilates the mucous membrane and submucous tissue, producing ickening of them. It also insinuates itself amongst the muscular ndles, frequently separating these and replacing them. It is not common to find in the muscular coat almost isolated outposts, the ncerous tissue having only a narrow connection with the primary mour. The cancer penetrates through the muscular coat to the bserous tissue, but does not commonly involve the surface of the ritoneum except in the case of colloid cancer (see under).

In their growth the cancerous processes irritate the tissues, and ere is usually a considerable infiltration of round cells. In the more ronic infiltrating forms, there is a great new-formation of connective ssue, constituting scirrhous cancer.

As the cancer in its growth causes atrophy of the proper tissue, the fected part of the stomach comes to be composed more or less of ncer tissue. This is less calculated to resist the disintegrating action the food and gastric juice than the normal mucous membrane, and nce **Ulceration** is a very frequent result. This will occur readily in e softer and more superficial cancers, and as these are the commoner, is usually a prominent feature.

The **Cancerous ulcer** (Fig. 580) is usually considerably excavated, and there may be pieces of slough in its floor. Its edges are prominent, sometimes over-hanging, and they shade off into the normal mucous membrane. In its central parts the ulcer may penetrate deeply sometimes through the coats of the stomach into neighbouring viscera, as the liver or tranverse colon. On the other hand, the floor of the ulcer may be partially cicatrized. In slow-growing epithelial cancers the ulcer may be very large and, with its overhanging edges, may occupy a large part of the stomach.

Cancer of the stomach usually begins in the **Pyloric region**, although by no means always. It may arise, for example, in the cardiac end (Fig. 581). In extending it not infrequently takes the form of a **Ring** around the pyloric region, and by its prominence and sometimes by the contraction of the ulcer may lead to obstruction (see Fig. 582).

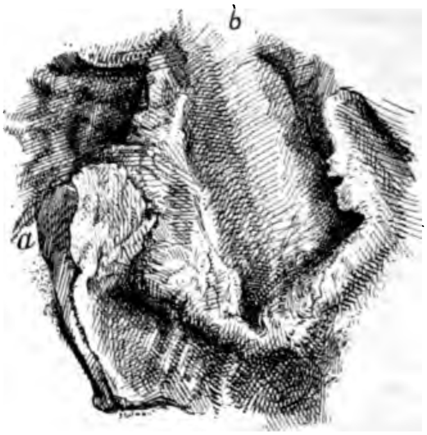

Fig. 580.—Ulcerated cancer of the stomach. The central depression of the ulcer and the prominent infiltrated border are shown.

Hypertrophy of the muscular coat of the stomach is present in most cases of cancer and is a striking feature in many. This arises from the fact that the cancer, by causing rigidity of the wall or by obstructing the pylorus, interferes with the peristaltic movement and so induces a compensatory hypertrophy of the muscle. Hence it is sometimes extreme in scirrhus and in pyloric cancers generally. The thickened muscular coat forms a somewhat stiff mantle, which on section has a pale glistening appearance, the trabeculæ of the muscle being separated by partitions which run perpendicular to the surface (Fig. 582).

he cancer affects surrounding parts both by Irritation and by ension of the cancerous growth. The peritoneal surface is usually

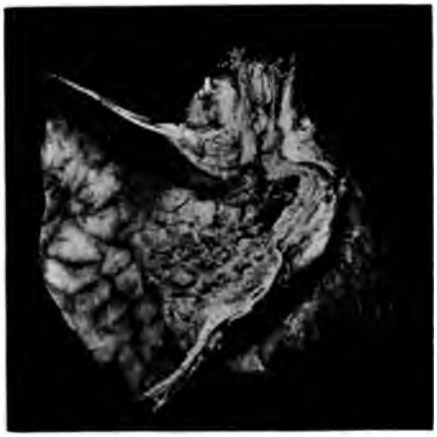

Fig. 581.—Cancer of the cardiac end of the stomach, with extension to the œsophagus, spleen, etc.

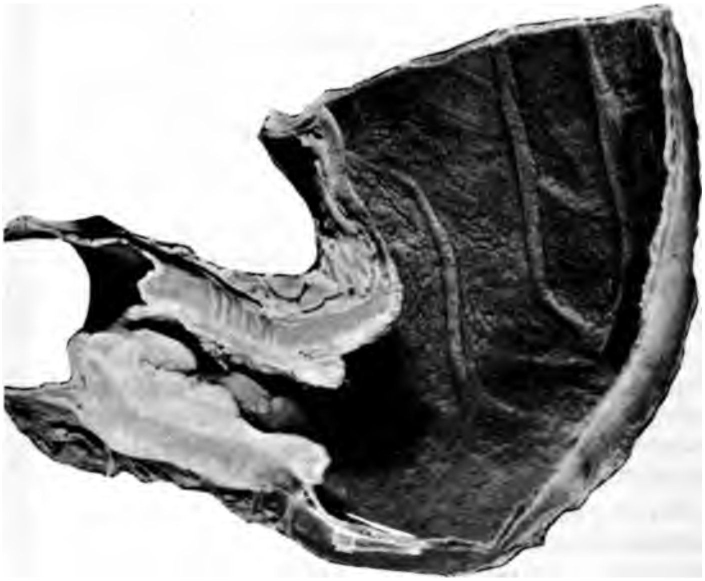

Fig. 582.—Cancer of the pyloric end of stomach, with marked stenosis. There is hypertrophy of the muscular coats.

seat of chronic inflammation, so that adhesions are present, some- s producing great matting and entanglements around the stomach.

The cancerous growth also sometimes extends by contiguity into organs with which adhesions have been contracted, chiefly the liver and transverse colon.

The **Lymphatic glands** are usually affected, in the first place those immediately in connection with the stomach at the lesser and greater curvatures, but also the prevertebral glands. A very frequent extension is to the **Liver** (which see) and a less frequent one to the **Peritoneum**.

As the secondary extension of cancers of the stomach and intestine presents may points in common, a special section is devoted to the subject further on.

The general characteristics of cancers of the stomach have been given above, and several forms have been referred to. It is possible to distinguish four different forms, which, however, are not absolutely separable.

1. **Cylinder-celled epithelioma** (*Adenoid cancer, Malignant adenoma*).—In this form there is a tolerably definite gland-like new-formation, as we have in other cases of cylinder-celled epithelioma (see Fig. 196, p. 360). There are spaces lined with cylindrical epithelium, but very often this regular arrangement is lost in great part, and, except in the more recently formed parts, we have more irregular masses.

The tumour is a slowly growing one, and it generally involves a considerable portion of the stomach before the death of the patient. The surface is nearly always ulcerated, and may be considerably excavated. There are sometimes papillæ on the surface of the tumour, especially at the marginal parts, which give the surface a warty appearance.

2. **Medullary or soft cancer.**—This form is closely allied to the preceding, but the cell masses are larger and less arranged in definite gland-like spaces, while there is a sparse and delicate stroma. The tissue is soft, and it is specially liable to bleed and to ulcerate. The latter condition is so frequent and characteristic that the tumour often presents itself as a round, shaggy ulcer, which may be very small and insignificant in appearance (see Fig. 583). The bleeding may be slight but frequent, or it may be more considerable and even fatal. This form very commonly shows numerous large tumours in the liver.

3. **Scirrhus.**—In this form the new-formation of epithelial cells is not very rapid or vigorous, and it is accompanied by an excessive formation of connective tissue in the form of a stroma. Originating in the glandular epithelium, long processes composed of rows of cells, often with few abreast, are produced. These processes seem to be peculiarly irritating, as they give rise to the production of round cells and of dense connective tissue, which are sometimes more manifest than the proper epithelial elements. These elements may, in fact, degenerate, and leave little besides condensed hard connective tissue.

The cancer mostly begins in the pyloric region, but extends inwards till, in some cases, it has involved the entire wall of the stomach, except the fundus. The wall of the stomach is converted into a stiff hard mass, which may be, in some places, an inch in thickness. The surface of the affected portion of the stomach is irregular, with rounded prominences, and there are sometimes ulcers present, but there is not a general ulceration as in the case of the epithelial and medullary forms. The affected portion of the stomach is often greatly contracted in this disease, especially the pyloric region (see Fig. 584).

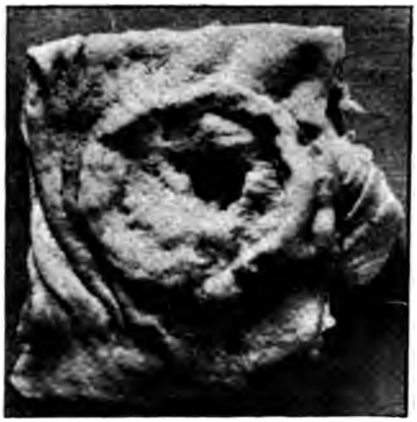

Fig. 583.—Cancer of stomach in the form of a circular ulcer with infiltrated walls.

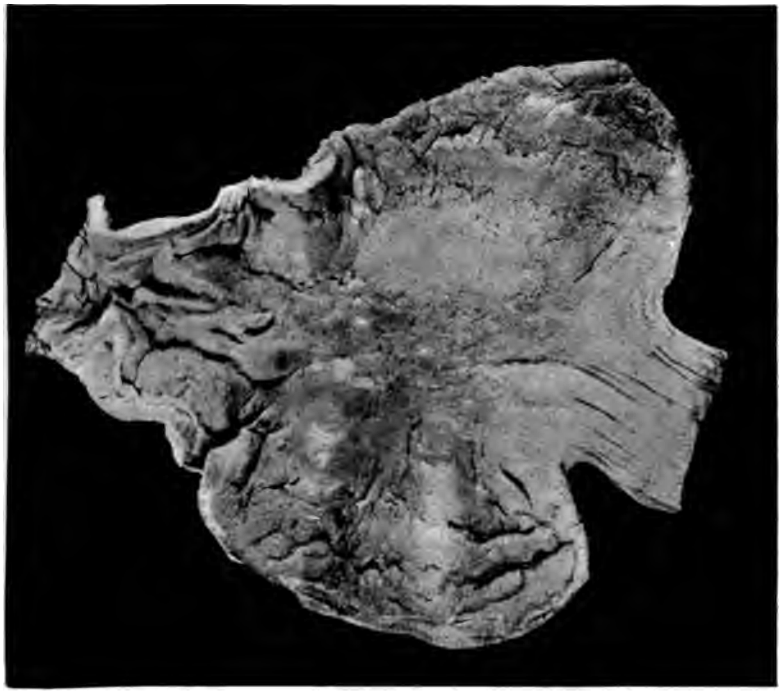

Fig. 584.—Scirrhus-cancer of the stomach. Almost the entire stomach is involved. The thickening is most marked at the pyloric end.

4. **Colloid cancer.**—The forms already described, and especially the epithelioma, occasionally undergo a partial colloid degeneration, but in colloid cancer the cells have a special tendency from the first to undergo colloid metamorphosis, so that even in the more recent parts there is often already a considerable advance in the degeneration. The outlines of the cells disappear as the protoplasm becomes transformed into colloid material, and as the nuclei resist the degeneration longer, we sometimes see the peculiar appearance of oval nuclei as if floating in a clear transparent material. Finally, the whole epithelial elements are converted into colloid material, and the structure presented is a beautiful reticulated network with spaces filled with a transparent colourless jelly (Fig. 202, p. 366).

As the colloid material occupies more space than the original cells, the spaces of the alveoli are, as it were, tightly packed with the jelly, and the fibres of the stroma rendered tense and rigid. Hence, although the structure is composed mainly of a soft jelly, yet it is to the feeling hard and rigid, just as a tensely filled bladder may be.

The tumour, like other cancers, usually begins near the pylorus, but it extends gradually till it comes to involve a large area, sometimes even as much as three-fourths of the entire extent of the viscus. The wall of the stomach is converted into a transparent glancing tissue, and in the more advanced parts it is impossible any longer to distinguish the different coats, all being homogeneously replaced by the cancerous tissue. The wall of the stomach is considerably thickened, and the internal surface may present an irregular aspect with prominences; but there is little tendency to ulceration. As the thickened wall is tense and hard, the stomach when cut into does not generally collapse, but keeps its shape. There is no tendency to contraction of the stomach as in scirrhus, but, on the contrary, the organ may be considerably enlarged.

This form has a very marked tendency to extend continuously both along the stomach and also through the stomach to the peritoneum. Hence it produces secondary tumours in the peritoneum itself much more readily than in the lymphatic glands and liver.

The remaining tumours of the stomach are of trivial importance. We have already seen that **Mucous polypi** and **Cysts** occur in chronic catarrh (see p. 958, and Fig. 156, p. 320). **Lipomas** and **Myomas** are occasionally met with. **Fibromas** and **Sarcomas** also occur, but they are rare.

Secondary cancer scarcely ever occurs in the stomach. There may be an extension from the lower end of the œsophagus of flat-celled epithelioma, and a few cases of metastasis have been observed.

VIII.—PARASITES AND ABNORMAL CONTENTS OF THE STOMACH.

Almost any of the commoner intestinal **parasites** may occasionally be found in the stomach. Among the more important of the vegetable parasites are the **Oidium albicans** and the **Sarcina ventriculi**. The former occasionally is seen in association with **Thrush**, involving the tongue and œsophagus. The latter deserves more special mention.

The sarcina is a micrococcus which in dividing shows lines of fission in three directions at right angles, so that it always divides into fours. The fours often remain adherent, so that we may have groups of four, eight, sixteen, or further multiples (see Fig. 585). There are several forms of sarcinæ which may appear spontaneously in various media, their source being the air, and from these pure cultivations may be obtained. The forms are distinguished by the colour of the cultures, as white, yellow, orange, etc. **Sarcina ventriculi** (Goodsir) is a form found in the stomach, especially when the organ is greatly dilated and processes of fermentation are proceeding. It occurs as cubical packets of micrococci which frequently have a brownish colour when seen under the microscope (see Fig. 585). When cultivated on nutrient media it grows in light yellow colonies. It has no special significance in the stomach, where it occurs along with other fermentative bacteria.

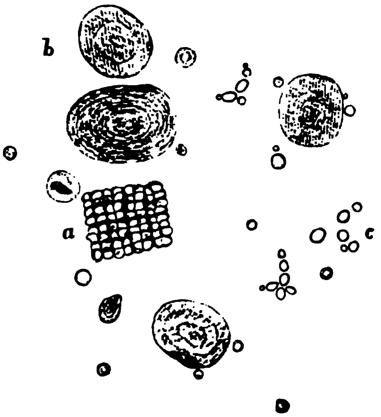

Fig. 585.—From vomited matter, showing (a) sarcinæ ventriculi, (b) starch granules, and (c) fungus spores. × 350.

Sarcinæ have also been observed in other situations. If blood be taken fresh from the vessels into a capillary tube and preserved in a water-bath at a temperature near that of the body, then in almost every case sarcinæ will develop in a few days (Lostorfer and Ferrier). They first appear as globular glancing bodies and then form the regular cubical packets. They are smaller than those found in the stomach, but in nutrient media they grow to that size. Sarcinæ have also been found in gangrenous cavities in the lungs, and in the urine, being probably derived from the blood.

Foreign bodies of various kinds are frequently swallowed accidentally or intentionally.

Felted masses of hair—**Hair balls**—are often met with in animals. They occasionally occur in insane or hysterical subjects. **Concretions** or **Gastroliths** are of very rare occurrence.

Literature.—*Myoma*—Virchow, Geschwülste, iii., 126. *Sarcoma*—Wickham Legg, St. Barth. Hosp. Rep., x., 1874; Hardy, Gaz. des Hôp., 1878, p. 25; Virchow, Geschwülste, ii., 325; Tilger (with literature), Virch. Arch., cxxxiii., 1893; Finlayson, (in infant) Brit. Med. Jour., ii., 1899. *Cancer*—Rokitansky (Adenoma), Lehrb., iii., 155; Hauser, Magengeschwür, Bezieh. zur Entwick. des

Carcinoms, 1883; MOORE (Cancer in child), Path. Trans., xxxvi., 1885; KÖSTER, Die Entwick. der Carcinome; EBSTEIN, Volkmann's Vorträge, 1875, No. 75; GRAWITZ (Metastasis of cancer, and literature), Virch. Arch., lxxxvi., 1881; COUPLAND, Path. Trans., xxvii., 1876, p. 264; PERRY and SHAW, Guy's Hosp. Reports, xlviii., 1891; FENWICK and FENWICK, Cancer and other tumours of the stomach, 1902. *Foreign bodies*—SCHOPF, Wien. klin. Wochenschr., 1899; FENWICK, Brit. Med. Jour., ii., 1902.

E.—THE INTESTINES.

Introduction.—The diseases of the intestines resemble in many respects those of the stomach, but there are important differences. In structure the intestine differs from the stomach in several respects. We no longer have the specific glands peculiar to the stomach, but, on the other hand, the intestine presents numerous closed lymphatic follicles in its mucous membrane, which are only present to a slight extent in the stomach. The lymphatic follicles are solitary or collected into groups, in the latter case forming the well-known Peyer's patches.

After leaving the stomach the food passes rapidly through the upper part of the small intestine, occupying on an average two and a half to three hours in doing so, and it is at the same time rendered alkaline and partially protected from further decomposition by the pancreatic juice and the bile. The movement of the intestinal contents is effected by the peristaltic contraction of the bowel, and the rapid passage of the contents through the small intestine indicates that here the peristalsis is peculiarly active, whereas, in the large intestine, it is slow. When the fæces reach the large intestine they are still fluid, and the chief function of the colon seems to be to complete the absorption of the fluid, and allow the fæces to become thicker. But if the peristaltic action of the large intestine be increased, then there will be no time for the fæces to become thick, and fluid evacuations will be the result. This will be still more the case should the movement of the small intestine be increased, and the contents carried through it even more quickly than usual.

It will be seen that **Diarrhœa** results from increased peristaltic movement, and that the evacuations will be more fluid the higher up the increased movement begins. Certain medicinal agents produce fluid motions, and these seem to act generally by increasing the peristalsis, although some appear to produce their effects by diminishing absorption or causing a transudation of fluid into the canal (Hay). Irritating articles of food produce a like increase of the peristalsis and consequent diarrhœa, and so may ulcers and inflammations.

In the stools in diarrhœa we may expect to find chemical constituents which normally are present in the higher parts of the intestine, but are absorbed before reaching the rectum. If the diarrhœa arise from increased peristalsis of the colon, then we shall find material which is normal in the cæcum, such as undecomposed bile, leucin, chloride of sodium, peptones, and sugar, some of which are present in appreciable quantities in normal fæces. But if the diarrhœa has involved the small intestine, then we shall find these constituents much more abundantly, and also remains of undigested food.

We have already seen in the case of the stomach that many of its diseases are connected with the fact that the food stagnates and decomposes in that viscus. It will be seen from what has gone before that the **intestinal contents stagnate** chiefly in the **Large intestine**, and next to that in the lower part of the small intestine. It is probably due to this that we find the jejunum peculiarly free from all forms of disease; in this respect contrasting with the lower part of the small intestine—the ileum—but still more with the large intestine. Hence it is that the diseases of the large intestine resemble those of the stomach much more than do those of the small intestine. This is especially true in regard to simple inflammations, which very often are concentrated on those parts where the intestinal contents most readily stagnate, namely, the cæcum and the rectum. It is true also of cancer, which is very rare in the small intestine but common in the large, especially in the cæcum and rectum.

It is to be remembered, further, that the intestine is a comparatively narrow tube, and is subject to obstruction in various ways.

Post-mortem changes.—These are not so important as those of the stomach. After death the blood is apt to gravitate towards the more dependent parts of the wall of the intestine, and the colouring matter being dissolved out and staining the mucous membrane, it may give rise to a deceptive appearance of inflammation. Similarly the intestine may be stained with the biliary colouring matter in the neighbourhood of the gall-bladder.

Literature.—COHNHEIM, Allg. Path., 1882, ii., 132; NOTHNAGEL, Phys. u. Path. des Darmes, 1884; HAY, Jour. of Anat. and Phys., xvii., 1883; MARKWALD, Virch. Arch., lxiv., 505, 1875; HEMMETER, Diseases of the Intestines, 2 vols., 1902.

I.—MALFORMATIONS OF THE INTESTINE.

Congenital malformations of the intestine are of considerable frequency. The most important are those in which, from a fault of development, a part of the intestine is wanting. These may be part of a general malformation, as in the case of the Siren-malformation (see p. 58). Of the more local malformations the most important are those in which the rectum is occluded. These cases which are included under the name **Imperforate Anus** (see Fig. 12, p. 56) are of very various degrees of completeness. The rectum may be absent, or it may be obstructed in its course or at the anus, the most hopeful cases from the surgical point of view being those in which only the extreme lower part of the rectum is defective, and the gut is separated from the anus only by a membrane.

There occur also narrowness and defect of the small intestine, especially in the duodenum and lower end of the ileum. The whole intestine is sometimes deficient in length, having something like the form of the letter S instead of the usual convolutions. In such cases the absorption and digestion of food must be defective, but the persons may live on to old age.

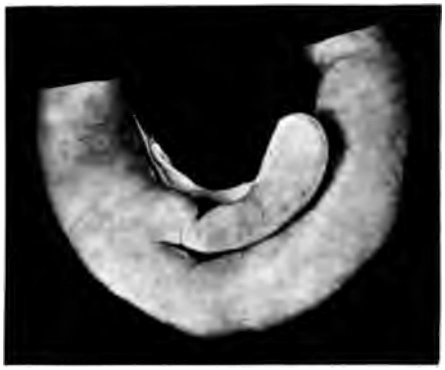

Fig. 586.—Meckel's diverticulum.

The commonest malformation is **Meckel's diverticulum.** This consists in a finger-like projection from the intestine. It occurs in the ileum, about three or four feet above the ileo-cæcal valve in the adult, and about a foot above it in the new-born; it projects usually from the free convex border of the gut. In Fig. 586 the diverticulum arises near the mesenteric border. It is from one to six inches long, possessing the same structure as the intestine, and communicating with the latter; it is narrower in its calibre, being of a diameter rather more than that of the finger. This diverticulum arises by the imperfect closure of the omphalo-mesenteric duct, and sometimes it is united to the umbilicus by a cord. Very rarely is the diverticulum continued to the umbilicus, and opens there, forming an **Umbilical fistula.**

Sometimes the diverticulum becomes closed more or less completely at its orifice by a fold of mucous membrane or otherwise. In that

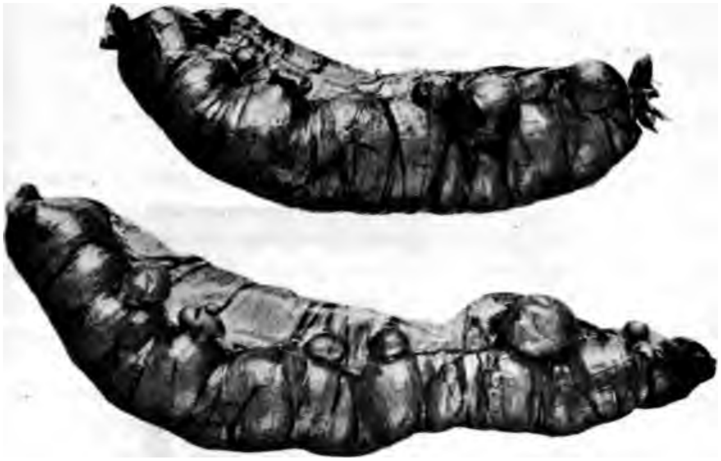

Fig. 587.—Multiple false diverticula of the small intestine. Dried preparation.

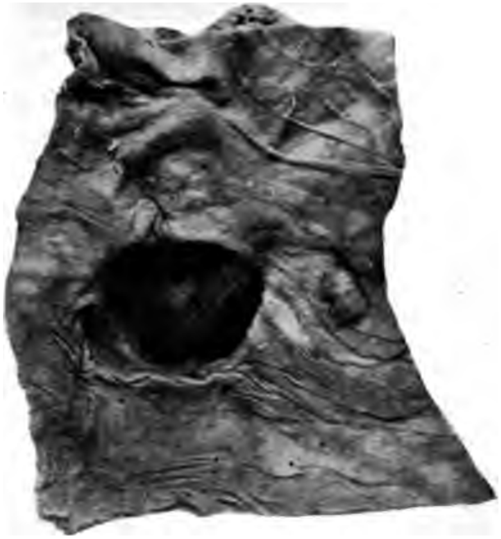

Fig. 588.—Large false diverticulum of the duodenum. The common bile duct is seen at the left margin of the pouch.

ase the accumulation of intestinal secretion in it may give rise to he formation of a cyst, the **Enterocystoma**.

Not infrequently the free end of a Meckel's diverticulum becomes adherent to some neighbouring structure. The bridge or band so formed may be the cause of an intestinal obstruction.

False diverticula.—The small intestine is sometimes the seat of numerous rounded pouches of various sizes, which are situated on the attached aspect of the intestine, extending partly into the mesentery (see Fig. 587). They are mostly composed of the mucous and serous coats alone, as if the muscularis had been defective towards the mesenteric attachment, so as to allow of the mucous membrane being pushed outwards. The duodenum is frequently the seat of single or double pouches (see Fig. 588). In the large intestine similar pouches may be present in large numbers (see Fig. 589).

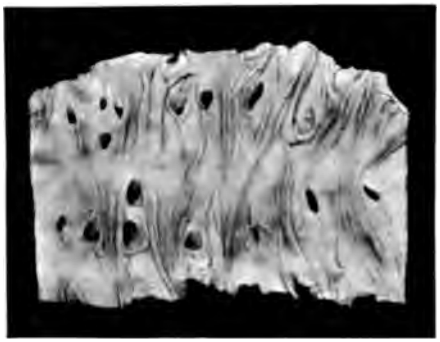

Fig. 589.—Multiple false diverticula of the large intestine. Viewed from within.

Literature.—LEICHTENSTERN, in Ziemssen's Encycl., vii., 1887; ORTH, Path. Anat., 1887, i., 764; BODENHAMER, Congenital malformations of the rectum and anus, 1860; FRANK, Ueber d. angeborene Verschliessung des Mastdarmes, Wien, 1892; FITZ (Omphalo-mesenteric remains, cysts, etc.), Amer. Jour. of Med. Sc., July, 1884; ROTH (Enterocystoma), Virch. Arch., lxxxvi., 371, 1881; RUNKEL, Ueber cystische Dottergangsgeschwülste, Marburg, 1897; RIMBACH, Zur Casuistik d. Enterokystome, Giessen, 1897; EDEL (Diverticula), Virch. Arch., cxxxviii., 1894; SUTHERLAND, Trans. Glas. Path. and Clin. Soc., vi., 1895-97.

II.—EMBOLISM AND HÆMORRHAGE.

1. **Embolism of the mesenteric arteries.**—Although the mesenteric arteries are not end arteries, yet embolism of the larger stems sometimes produces hæmorrhage and necrosis, the process being similar to that in hæmorrhagic infarction. The hæmorrhage may be very considerable. If the patient survive, the slough after separation leaves an **Ulcer** (the *Embolic ulcer*, Parenski).

Very few cases of this kind have been examined post mortem, and in these it has been the superior mesenteric artery which has been plugged. There is, however, some reason to believe that embolism of the inferior mesenteric artery may have similar results. Both of these vessels have anastomosing communications, but they are insufficient to restore the circulation in the central parts of the area to which the vessels are distributed, although they do so at the periphery. Hence, the infarction is less in extent than the area of distribution. The subject has been very fully elucidated by the experiments of Litten.

2. **Hæmorrhage.**—Besides the rare form just mentioned, we have hæmorrhage resulting from various causes. Ulcers of various sorts lead to it, especially cancerous and typhoid. Passive hyperæmia is also not infrequently a cause, especially when it depends on obstruction of the portal system in the liver. In this case the hæmorrhage is more liable to be from the large intestine than the small. Intussusception and hernia, by obstructing the vessels, may induce hæmorrhage by a local passive hyperæmia.

Literature.—LITTEN, Virch. Arch., lxiii., 1875; MOYES (literature fully), Glasg. Med. Jour., xiv., 1880; GRAWITZ, Virch. Arch., cx., 1887; PARENSKI, Wien. Med. Jahrb., iii., 1876; WELCH, Allbutt's Syst. of Med., vi., 1899.

III.—HERNIA OR RUPTURE.

True hernia consists in a protrusion of the intestine, omentum, or other abdominal organ into a sac formed by a prolongation of the peritoneum. The sac may project externally, or it may be contained within the abdomen, and so we may distinguish **External** and **Internal** hernias. The hernias, especially the external ones, are of so much importance from a surgical point of view that full descriptions are given in surgical and anatomical text-books, and need only be repeated here in outline.

For the most part the sac is an entirely abnormal projection of the peritoneum. An exception to this occurs in the case of congenital inguinal hernia, in which the sac is formed by the persistence of a fœtal condition. There is a partial exception also in the case of most internal hernias, where the sac usually arises by the exaggeration of an existing normal pouch.

Causation of hernias.—Hernias are usually ascribed to the abdominal contents being subjected to **undue pressure.** In severe muscular efforts, such as are involved in lifting heavy weights, the glottis is closed, and the muscles of expiration fix the chest and abdomen, the contents of the abdomen being subjected to severe pressure by the contraction of the muscles of the abdominal wall. If there is any part of the wall which is unduly weak a bulging outwards may occur here, and so give the starting point for the hernial protrusion.

In this connection the greater frequency of hernia on the right side may be noted. In violent exertions the right arm is usually more used than the left, and as the chest is bent over to the left side to counterbalance the strain on the right, the lower surface of the diaphragm faces more to the right and presses the viscera towards that side. It is clear that straining at stool or otherwise will also increase the pressure on the abdominal contents, and any excess will predispose to hernia.

The protrusion takes place where there is any **Weakness of the abdominal wall.** The external hernias occur at specially unsupported parts of the wall, while the internal ones have usually a pouch ready made as a starting point. The abdominal wall from its anatomical conformation is weak at certain points in every person, but there may be congenitally a special weakness, which in some cases seems to be hereditary. On the other hand, when the abdominal contents are increased, as a result of tumours, fluid accumulation, or pregnancy, the stretched wall may be weakened. It may be so also from direct injury to the wall.

Another cause is sometimes assigned for the production of hernias, namely, an abnormal elongation of the mesentery. It is supposed that such a lesion will allow the intestine to impinge unduly against the abdominal wall, especially at its lower parts.

The hernial sac.—The viscera nearly always push the peritoneum before them, and the proper sac is formed by the peritoneum, which shows a remarkable power of stretching. But there are cases of protrusion in which the aperture has been produced by actual rupture of the peritoneum, and in these cases the hernia may be devoid of a proper sac. These cases, however, of what may be called **False hernia**, are exceedingly rare, as an injury, although tearing the muscular wall and other tissues, generally leaves the elastic peritoneum uninjured and capable of protrusion.

In **Congenital hernias** the sac is formed of peritoneum, but there has been no actual protrusion. In congenital inguinal hernia the sac is formed by the tunica vaginalis, the connection of which with the peritoneum has remained patent. In congenital umbilical hernia the peritoneum is prolonged into the umbilical cord (see p. 55).

The hernial sac usually **acquires adhesions** to the structures among which it is protruded, and it does so by a chronic inflammation. It very often happens also that the contents of the sac become adherent to its internal surface by inflammation, and in that case the hernia is irreducible.

Forms of hernia.—It is not necessary to enter fully into the individual forms of hernia, and of the external ones little more than an enumeration will suffice.

The external hernias are, (1) Inguinal hernia in the congenital and acquired forms, or, as otherwise divided, direct and oblique; (2) Femoral hernia. These two are by far the commonest forms. Of comparatively rare occurrence are, (3) Hernia of the sciatic notch; (4) Perineal hernia, protruded between the fibres of the levator ani; (5) Vaginal hernia; (6) Hernia of the foramen ovale; (7) Umbilical hernia, which is congenital or acquired, in the former case arising by protrusion into the dilated umbilical cord; (8) Abdominal hernia occurring in various parts of the abdominal wall, chiefly towards the edges of muscles, and arising by tearing of tendons or muscular fibres, hence frequently traumatic; its commonest situation is near the linea alba; (9) An interesting form of hernia is that in which the testicle having descended imperfectly the protrusion takes place into the sac around the misplaced testis. This sac will occupy at first the position of the inguinal canal, but it is liable to enlarge so that there may be a considerable sac in the substance of the abdominal wall.

Internal hernia comes less frequently into sight, and the possibility of its existence is apt to be forgotten.

1. **Diaphragmatic hernia** is perhaps the commonest. There is a congenital form in which a sac is protruded through one of the normal apertures, or through a part of the diaphragm which by reason of defective development has given way. The protrusion is into the chest, and the sac may contain the intestine, spleen, liver, or stomach. There is also an acquired form, due nearly always to some injury to the diaphragm, and the hernia is frequently devoid of a proper peritoneal sac.

From a case recorded by Dr. Adams, it appears that a tumour growing against the diaphragm (in his case from the capsule of the spleen) may so weaken it as to lead to hernial protrusion. In diaphragmatic hernias from rupture, a large portion of the abdominal viscera may be protruded.

2. **Retroperitoneal hernia** includes cases in which the intestine passes into a pre-existing pouch in the peritoneum, greatly enlarging and filling it. The hernial sac hence lies behind the peritoneum of which it is an offset. There are three principal pouches in the peritoneum which are capable of giving rise to such hernias.

In *fossa jejuno-duodenalis* is the most important. It exists just where the jejunum arises from the duodenum, and lies between the last part of the duodenum, which bounds it on the right, and the aorta, which bounds it on the left. The pouch was present, according to Waldeyer, in about 70 per cent. of the bodies which he has examined, and is generally large enough to admit the terminal phalanx of the thumb. It is best seen when the jejunum and small intestine generally are raised and carried to the right, so that the origin of the mesentery may be exposed. The little pouch, if present, is then seen lying in the posterior wall of the abdomen with a sharp sickle-like margin. Sometimes a fold of the jejunum passes into this pouch, constituting a hernia. The pouch may be greatly enlarged by the protrusion of further portions of the intestine into it, and cases have been recorded in which the entire intestine has passed into the greatly distended sac.

The *fossa subcæcalis* has its seat between the folds of the meso-colon ascendens. Into this pouch the intestine is very rarely protruded, and the pouch itself only occurred in about 30 per cent. of the bodies examined by Waldeyer.

The *fossa intersigmoidea* is a pouch in the meso-colon of the sigmoid flexure lying between its two folds. The aperture is in the under layer. This is the commonest of these pouches, occurring in about 80 per cent. of the bodies, but from the position of the aperture it does not appear ever to become the seat of hernia.

Contents of hernias.—The parts protruded are usually the intestine, and, for the most part, the more movable small intestine. Sometimes also the great omentum is carried into the sac. The urinary bladder, large intestine, or any part of the contents of the abdomen, may, under exceptional circumstances, pass into the sac.

As the contents of the sac are unduly exposed to pressure, stretching, and friction, there is apt to be a **Chronic peritonitis** set up in the wall, especially in old cases. This may unite the loops of intestine together. In the case of large hernias with wide necks there may thus be produced complete matting of the intestine. It even happens that if the hernia be such as to allow successively of the descent of any part of the small intestine, the whole of the small intestine may be mutually adherent.

If the intestine be long retained the chronic inflammation may induce adhesion of the intestine to the internal wall of the sac, and the hernia becomes **Irreducible**. It may be irreducible from other causes, such as narrowness of the neck, protrusion of an excessive bulk of viscera, etc.

The mode of descent of the **Large intestine** merits special notice. The sigmoid flexure, being freely movable, may be protruded just like the small intestine, and the cæcum or transverse colon may also sometimes pass into a sac in a similar fashion, but otherwise the large intestine having no mesentery and being only partially covered with peritoneum does not usually descend. When it does its descent is in some respects comparable with that of the testis in the fœtus. Before its descent the testis lies behind the peritoneum and is only partially covered by it. As it descends it remains with only a partial peritoneum covering, and even in the tunica vaginalis, after the sac has separated from the general peritoneum, the testis lies behind with its posterior aspect free of peritoneum. And so in a hernial sac, the cæcum may be carried down, but in its new position it remains only partially covered with peritoneum, and really forms, as it were, a part of the wall of the sac. This will only occur in very large hernias as a rule, but when it does occur the piece of intestine will be irreducible.

A still more peculiar condition sometimes occurs. The intestine may be protruded mainly at the part where it is uncovered by peritoneum, and instead of pushing a peritoneal sac before it, it may, as it were, drag one after it. As the gut is protruded it may even get more and more stripped of peritoneum, so that the hernia may be much more extensive than the sac. This, however, is a very exceptional occurrence, and it is more common to find that as an ordinary hernia advances it drags the colon into it, so that besides free loops of small intestine there may be, fixed in the wall and only partly covered by peritoneum, a piece of the cæcum, or the sigmoid flexure, or even the fundus of the bladder.

In a similar fashion to that just described, the ovary may be protruded. A large majority of cases of **Ovarian hernia** are congenital, and they appear to arise by a fault of development by which the ovary descends as the testis does normally. The ovary passes through the inguinal ring and takes a sac with it, but just like the testis it is itself attached to the wall. The sac remains open like the tunica vaginalis in a congenital inguinal hernia. The ovary in that case will be irreducible, unless, as sometimes happens, the broad ligament is so long as to allow the ovary to pass back through the neck. In this case, however, the ovary will still have its fixed attachment in the sac. Apart from this congenital inguinal form, ovarian hernias may be acquired, and these may be either inguinal or femoral. Several cases of obturator hernia of the ovary are on record. (See Fig. 590).

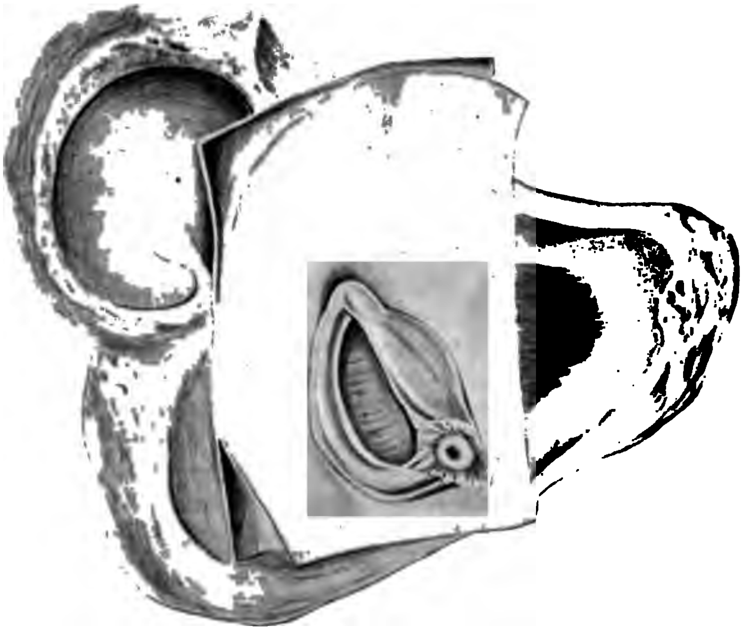

Fig. 590.—Obturator hernia of the right ovary and Fallopian tube. (Dr. Lickley's case.)

Strangulation and Incarceration.—These terms express a condition in which the contents of the sac are caught tightly at the neck, so that there is not only a hindrance to their return but an excessive pressure interfering with the circulation.

This mostly occurs when, on account of some peculiarity in the situation of the intestine as it issues from the sac, there is, to begin with, a partial obstruction. If the intestine at its entrance into the sac be free, while at its exit it makes a sudden bend so as to cause a partial obstruction, then the fæces will pass readily in, but will accumulate inside as they do not find free exit.. The mere loading with fæces may cause irreducibility, and if the fæces decompose the development of gas may still further increase the bulk of the contents. In this way the sac will become too full, and as the neck is narrow there will be special constriction here. Again, the intestine already in the sac, by its peristaltic movement, may drag more and more of the gut after it, till the intestine may become impacted at the neck.

In any case the neck of the sac constricts the portion of intestine concerned, and the most direct effect is **Obstruction of its veins.** This itself, by producing hyperæmia, and, it may be, œdema of the mucous membrane, leads to swelling and further constriction. The whole protruded piece becomes of a dark colour from venous engorgement and hæmorrhage. Finally the pressure may be enough to close even the arteries.

The venous obstruction alone seems sufficient, if complete, to cause necrosis of the intestine, and so **Gangrene** is an occasional result. If the arteries are also obstructed there is still greater probability of the occurrence of gangrene.

Sometimes the obstruction is relieved before gangrene has occurred, and yet in some of these cases a severe inflammation results after the intestine has been returned to the abdomen, leading, it may be, ultimately to gangrene of the affected piece of gut. The probable explanation of this is that, during the incarceration, the blood-vessels have been so damaged that, on the restoration of the circulation, they are unable to recover. It has been shown by experiment (in the ear of the rabbit) that if, by closing the main arteries, the vessels of the part are deprived of blood for a time, and then the circulation restored by loosing the ligature, the result is active hyperæmia, acute inflammation, or hæmorrhagic infarction, according to the time during which the ligature has acted. So in the case before us, the release of the constriction, by allowing of the re-establishment of the circulation in vessels seriously affected, may lead to inflammation or gangrene.

Literature.—For external hernias see surgical and anatomical works. Wood, in Ashurst's Encycl. of Surg., 1885, v.; Bowditch, Diaphragmatic hernia, 1853; Garlick, Path. Trans., 1878, xxix. ; Baker (Pericardial diaphragmatic), ibid., 1877, xxviii. ; Adams, Glas. Med. Jour., 1880, xiv., p. 353; Waldeyer, Virch. Arch., lx., p. 65, 1874; Balfour, Edin. Med. Jour., 1869; Eve, Lancet, 1885; Englisch (Ovarian hernia), Stricker's Med. Jahrbücher, p. 335, 1871; Albert (Hernia inflammata), ibid., 239, ; Fredet (obturator), Rev. d. Chirurgie, 1901; Lickley, Glas. Med. Journal, March, 1902.

IV.—TWISTING OF THE INTESTINE. VOLVULUS.

This is a condition of frequent occurrence, but one which is perhaps too little borne in mind as a cause of obstruction. It occurs in the great majority of cases at the **Sigmoid flexure** of the colon. The descending colon above the flexure, and the rectum below it, have virtually no mesentery, being fixed to the abdominal wall. The flexure therefore is fixed at its two extremities and these are near one another, while the loop forming the flexure is movable. It is as if the loop were attached by its two ends to a fixed point, and it is easy to understand how it should sometimes twist round this as an axis. The twist is, as it were, in two half turns (see Fig. 591), and it is usually the upper limb of the loop which turns round the lower at its neck.

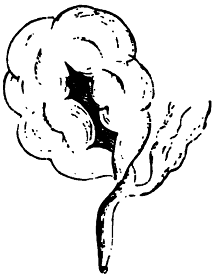

Fig. 591.—Twisting of the sigmoid flexure. The upper limb has a much sharper turn than the lower. A flexible tube could be passed up from the rectum.

The twisting causes some obstruction of the intestine, but this is not usually complete. Fæces still pass into the flexure, and may accumulate in enormous quantity. This partial obstruction with accumulation of fæces may persist for months and lead to extreme dilatation of the flexure, so that it may fill the abdomen and reach up to the diaphragm. The walls of the intestine in these prolonged cases may be greatly thickened, especially the muscular coat. In some cases twisting may exist without any obstruction of consequence.

Whilst twisting is most common in the sigmoid flexure, it is liable to occur also when other parts of the intestine assume similar relations, that is to say, when a free loop of small intestine becomes fixed at its extremities, and these extremities are near each other. This happens most frequently when one extremity is normally fixed, as is the case at the upper and lower ends of the small intestine where on the one hand the duodenum, and on the other the colon, is fixed to the abdominal wall and holds the intestine down. If, by inflammation or otherwise, an abnormal adhesion is acquired so that the gut is fixed at a point near the situation of the natural fixation, then twisting is apt to occur, and probably more readily here than in the sigmoid flexure, as the small intestine is naturally more mobile.

The author has recorded a case in which peritonitis had fixed the small intestine about a foot above the ileo-cæcal valve, so as to bring about the conditions named, and twisting occurred in consequence. A fixation may also be brought about by a Meckel's diverticulum which has retained its connection with the umbilicus (Coupland's case).

Literature.—Coats, Glasg. Med. Jour., xiii., 1880, p. 445; Coupland, Path. Trans., xxxi., 1880, p. 144; Reimers, Volvulus d. Flexura sigmoidea, Inaug. Diss., Greifswald, 1896.

V.—INTUSSUSCEPTION AND PROLAPSE OF THE INTESTINE.

1. **Intussusception or Invagination.**—In this condition one portion of the intestine passes into another. In order that one piece may slip inside another, the one must present active peristaltic contractions, while the other is relaxed. The portion narrowed by the violent peristalsis passes inside of the relaxed part. This usually occurs in the natural direction of the peristalsis, but it may be reversed.

The condition is most frequent in children in whom the peristalsis is very active, and in whom also the large intestine is more freely movable than in adults.

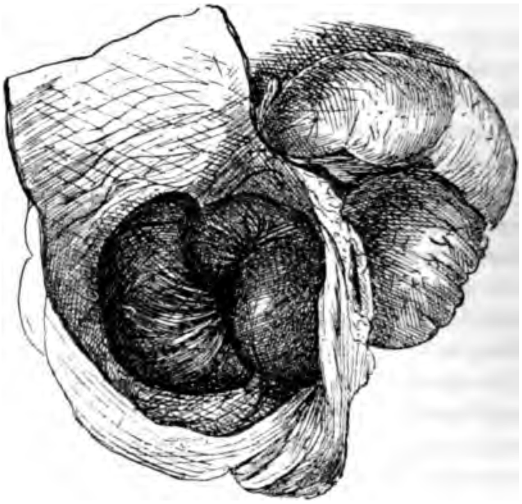

Fig. 592.—Intussusception. The colon is laid open and several coils of ileum are shown, which have protruded through the ileo-cæcal valve. One of the coils was gangrenous.

These conditions are most frequently satisfied at the junction of the small and large intestines. The large intestine is naturally wide, and its peristaltic movements are sluggish. If then the ileum at its last part presents peculiarly violent peristaltic contractions it may pass into the large intestine as in Fig. 592. The invagination, however, is not usually a simple inversion of the ileum into the colon ; in most cases the ileo-cæcal valve is carried before the advancing ileum and forms the apex of the intruded piece. This implies that the cæcum itself is carried inwards and inverted, and the orifice of the vermiform appendix is sometimes to be found near the apex of the invagination. The invagination is not infrequently extreme, and the invaginated part may be carried right on to the rectum, so that the apex may be felt *per anum.*

Besides this form we also meet with invagination of the large intestine itself, one part into a succeeding part. It occurs but rarely in the small intestine. (See Fig. 593.)

In the bodies of children, especially those who have died from cerebral or intestinal affections, we frequently meet with a form of invagination which has produced no symptoms during life, and has really occurred just at the time of eath. It is usually present in the small intestine, where a small inversion of ne part into a succeeding one is found. The invagination is easily reduced by light dragging, and there are none of the secondary changes visible, such as are to e mentioned immediately as following invagination. Just at death, or immediately fter it (as may be frequently seen in animals), the intestine commonly shows iolent peristaltic movements, but these are irregular, and it readily happens that much contracted part passes inside a relaxed portion.

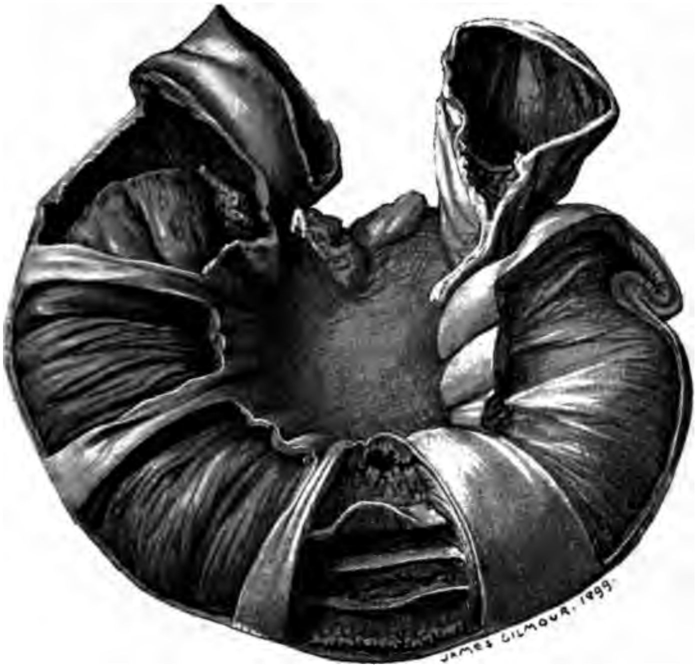

Fig. 593.—Large intussusception of the small intestine.

When a piece of intestine is invaginated, there are three tubes, the utside one in its natural position, forming the sheath, the internal ne, which, although abnormal in position, runs in the usual direction, nd the middle one joining the other two, with its mucous surface directed outwards. There is frequently a more complicated condition than this, the intestine being tightly packed in several layers. The mesentery is carried in with the intestine, and by being dragged on at one side, it may give the gut a somewhat oblique direction. In the process of invagination the peritoneal surfaces are applied against each other as are also the mucous. It is characteristic of the peculiarities of these two structures that the peritoneal surfaces very readily coalesce and become permanently adherent, while the mucous surfaces do not.

The packing of intestine causes considerable interference with the circulation, and this is increased by the mesentery being partly included and its vessels pressed on. The obstruction to the calibre of the intestine is thus associated with hyperæmia, œdema, hæmorrhage, inflammation, and even gangrene, just as in an incarcerated hernia. The inflammation may lead to general peritonitis; or the separation of a gangrenous part may allow of the escape of the intestinal contents and lead to a fatal peritonitis. On the other hand, permanent adhesion may occur, between the sheath and the upper end of the included part, at the proximal extremity of the invagination, and, the inner and middle tubes becoming gangrenous, they may come away in whole or in part, as a slough, and the continuity of the intestine be restored with the loss of a piece. It is not usual for complete gangrene of the included tubes to occur, but what remains becomes adherent to the sheath, and, by contraction, gradually accommodates itself, and so the calibre is fully restored.

2. **Prolapse of the intestine.**—This condition is the protrusion of the intestine outside the body through the anus or through an artificial anus. The commonest form is the ordinary **Prolapsus ani.** This only occurs when the sphincter is greatly relaxed by catarrh or by violent pressing at stool, but when it has frequently happened the sphincter atrophies and the prolapse occurs very readily.

There are, strictly speaking, two forms of prolapsus ani. In the one little more than the mucous membrane is protruded, and is seen to be continuous with the skin at the anus. In the other form there is really an invagination as well as a protrusion. The lower part of the rectum is so fixed that the whole wall cannot be protruded, but only its mucous membrane as in the form just considered. But the upper, more movable part may be invaginated into the lower part and then protruded. This mostly occurs as a consequence of violent peristaltic contraction of the rectum in cases of severe diarrhœa with tenesmus.

In both forms the exposed mucous membrane becomes inflamed and is liable to bleeding. The inflammation sometimes causes through time adhesion and fixation of the bowel in its abnormal position.

VI.—INFLAMMATION IN AND AROUND THE INTESTINE. ENTERITIS.

We have already seen that the mucous membrane is frequently irritated by the contents being of an obnoxious nature by reason of decomposition or otherwise. In addition to this, inflammation may be produced by the action of specific morbid poisons, chiefly those of dysentery, typhoid fever, and cholera. We have therefore in the first place to consider the simple and afterwards the other inflammations.

1. **Catarrh.**—Catarrhal inflammations of the intestine are very common in children and can usually be traced to the character of the ingesta, perhaps along with exposure to cold. The common autumn diarrhœa, which is so fatal to children, is generally due to improper food. Cold, by interfering with digestion and peristaltic action, may induce the intestinal contents to stagnate and decompose. The influence of the intestinal contents in producing catarrhs is shown by the localities at which inflammations are most common. The large intestine is much more frequently affected than the small, and in the large intestine the cæcum, with the vermiform appendix, is the most frequent seat, next to that the rectum.

The catarrh may be **Acute** or **Chronic**. It is characterized by hyperæmia and swelling of the mucous membrane, with exudation of serous fluid and leucocytes. There is also increased secretion of mucus, which in the case of the colon may be very excessive. The exudation is usually **Mucous** in character, but in the more acute inflammations it may assume more or less of a **Purulent** character. If this be the case the mucous membrane is liable to be infiltrated with inflammatory cells, and after a time to undergo **Ulceration**. This occurs with peculiar frequency in the cæcum, and next to it in the rectum.

Catarrhal ulcers are usually of considerable area and are comparatively superficial. Neighbouring ulcers may coalesce so as to produce extensive, variously shaped losses of substance, in the midst of which the remaining mucous membrane appears as raised patches with irregular outline. Sometimes the floor of the ulcer is so smooth, and the remaining mucous membrane so irregular from inflammatory infiltration, that it looks as if the ulcer were the normal mucous membrane and the patches of persisting mucous membrane adventitious. The ulcers of ordinary catarrh are superficial, and unless exposed to continued irritation, as by the prolonged presence of hard fæces, they do not tend to perforation, and readily heal when the cause of catarrh is removed.

In the course of catarrhs, ulcers also arise from the **Closed follicles.** There are indeed some catarrhs in which the latter are mainly affected, appearing as rounded prominences and flat elevations, corresponding to the solitary follicles and Peyer's patches. This form is called **Follicular enteritis.** The follicles may be so infiltrated with inflammatory products as to form virtually small abscesses, resulting in crater-shaped ulcers which may afterwards enlarge. In this way arise the so-called **Follicular ulcers.**

A frequent result of catarrh is **Atrophy.** This occurs as part of the induration of the mucous membrane which follows chronic inflammation. The atrophy affects first the mucous membrane, its glands being specially involved, but it may extend to the submucosa and even to the muscular coat. According to Nothnagel, atrophy is of very frequent occurrence.

Another result is **Hypertrophy** of the mucous membrane such as we find so frequently in the case of the stomach. Here also there may be **Mucous polypi** and **Cysts** as in the stomach. They are most frequent in the large intestine, and if seated in the rectum they may project through the anus.

A condition of not infrequent occurrence is **Enteritis membranacea.** In this disease considerable pieces of membrane are passed at stool, sometimes in hollow cylinders as if casts of the intestine. These are composed of mucus, with epithelium entangled in them. They are generally regarded as the result of chronic catarrh of the large intestine, but Nothnagel asserts that inflammation is not necessary, and that it may be the result merely of defective peristaltic action allowing of accumulation of mucus in the folds of the large intestine. Hence Nothnagel suggests the name Colica mucosa.

Psilosis or **Sprue** is a remitting chronic catarrhal inflammation of the alimentary tract, the nature and causation of which are still obscure. The disease occurs in tropical and subtropical climates and chiefly affects European residents. Diarrhœa is usually a marked symptom with anæmia and wasting. The mucous membrane of the mouth and tongue is often inflamed and eroded, and in the early stages presumably the lower parts of the alimentary tract are similarly affected. In the late stages marked atrophy occurs, the intestines being often specially affected.

2. **Phlegmonous and Diphtheritic inflammations.**—Some cases of catarrh have a more acute character, and assume the characters of suppurative or phlegmonous inflammation, the conditions approximating to those in severe dysentery (see further on). Such conditions are due to peculiar virulence in the intestinal contents, and may be brought about by irritant poisons. There may also be an acute inflammation in diphtheria. The relation of these conditions to the intestinal contents is shown by the fact that they occur chiefly in the large intestine and in the parts where the contents are especially prone to lie, namely, the cæcum, the flexures and the rectum.

3. **Localized inflammations.**—It has already been indicated that rtain localities are more liable to inflammation than others, and as the flammations of certain of these regions present special points of portance they have received special names.

Duodenitis is usually an extension of a catarrh of the stomach, and would not warrant any special reference except from the fact that e **Common bile duct** often takes part in the catarrh, and we have struction and **Icterus** sometimes resulting from this simple cause.

Typhlitis and Perityphlitis designate conditions which require very ecial notice. These two terms mean respectively inflammation in d around the cæcum, but they are frequently used so as to include flammations in connection with the vermiform appendix.

In some cases the cæcum is very seriously inflamed and ulcerated, pecially when large masses of hard fæces lodge in it. Under these cumstances the ulcers may increase in depth, and extend, in the sterior part of the wall where the gut is not covered by peritoneum, rough the entire thickness of the intestine so as to penetrate into the tro-peritoneal connective tissue. The result is acute inflammation in is region, often going on to the formation of **Abscess**, a condition signated **Perityphlitis.**

Inflammations in connection with the Vermiform appendix. ppendicitis.—Acute inflammations in this region much more frequently ise in connection with the appendix than with the cæcum. Inflamations are frequently caused by the presence of **Foreign bodies** in the pendix. Any hard substance lying in the cæcum may, if small ough, pass into the vermiform appendix. In this way apple, grape, erry, or orange seeds are said to get into it. But much more freently pieces of hardened fæces are met with, and as these become dry d frequently assume the shape and appearance of cherry or orange ones, they are frequently mistaken for them. This occurs all the ore because the inspissated fæces are often coated with phosphates hich form a kind of rind.

The presence of the foreign body causes inflammation of the mucous embrane, and this, from the continued pressure and confined space, adily results in ulceration. To these conditions the term Appendicitis properly given, but it is often extended to the resulting lesions, which e much more important than those of the appendix itself. The cers frequently penetrate through the appendix and lead to ritonitis. As a general rule the appendix has acquired adhesions fore actual perforation occurs, and so the peritonitis is limited by the hesions. But the inflammation is apt to return, and not infrequently sults in the formation of recurring abscesses. The bursting of one of these into the cavity of the peritoneum often leads to **Fatal peritonitis**. Sometimes the suppuration in connection with the vermiform appendix is in the **Subperitoneal tissue**. An abscess so produced may extend long distances beneath the peritoneum. The result is not infrequently a chronic peritonitis with considerable matting around.

The author met with a case in which an abscess connected with the vermiform appendix extended across the brim of the pelvis to the left side of the abdomen, and thence upwards beneath the peritoneum till it reached the diaphragm. It then penetrated the diaphragm and discharged itself into the pleural cavity.

Proctitis and Periproctitis are inflammations in the rectum and around it, of an equivalent character to those in and around the cæcum. If the ulceration leads to perforation and the formation of abscess, then the disease may have a very chronic course with fistulæ discharging into the rectum. Sometimes these open externally, or into the vagina, and they may retain their communication with the rectum, so forming false passages for the fæces and flatus; or the internal aperture may close, leaving merely an external fistula.

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VII.—SPECIFIC INFLAMMATIONS OF THE INTESTINE.

1. **Dysentery.**—In this disease we have a violent inflammation determined by the presence of an intense irritant. The disease occurs in a sporadic and an endemic form. As already mentioned, the infective agent, in one form, is believed to be an animal parasite, the amœba coli (see page 411).

The virus is introduced chiefly by the drinking water, and it acts on the mucous membrane directly. The locality of the lesion is apparently determined by the stagnation of the contents. It is essentially a disease of the large intestine, and is generally most intense in the rectum. It usually decreases in intensity from the rectum upwards, but not uniformly, there being more affected and less affected parts, the former corresponding usually with the flexures. In severe cases the whole colon is affected, and sometimes even the lower part of the ileum.

In the earlier stages the mucous membrane is swollen by serous udation. It is soft and thrown into folds, the summits of which e peculiarly hyperæmic. The surface is covered by a mucous grumous material, consisting of shed epithelium with mucus d inflammatory exudation. The mucous membrane and submucous sue are infiltrated with serous fluid and leucocytes in great undance.

In higher degrees the mucous membrane is still more thickened and rown into still more prominent folds. There is also considerable morrhage in its substance occasionally. The summits of the folds ing specially exposed to mechanical irritation commonly undergo **crosis**, and the sloughs are generally distinguishable by the **Brown lour** which they assume from becoming stained with the bile pigment. e necrosis involves the mucous membrane to varying depths, some- nes very superficially, sometimes through its whole thickness, and, if e slough surrounds the gut, we may have a ring of necrosed tissue imately discharged by the anus.

These sloughs leave **Ulcers** behind, whose walls present great iltration of leucocytes. But ulcers form also by processes similar to ose in catarrh, namely, by inflammatory infiltration and molecular struction of the mucous membrane, and by suppuration of and ound the closed follicles.

In some cases the solitary follicles seem to be specially involved, and some thors even distinguish a follicular form of dysentery, but the follicles are bably affected in the early stages of almost all cases, and partake in the general lammation. By suppuration of the follicles there may be the formation of merous ulcers with small apertures.

The contents of the intestine are in severe cases formed of dark composing material, mixed with blood. The mesenteric glands are ways secondarily affected, being enlarged and hyperæmic.

If the patient survive the acute attack, the disease very commonly sses into **Chronic dysentery**. The ulcers formed in the various ways scribed above show little tendency to heal, but remain as open scharging sores. Sometimes they penetrate more deeply and lead abscesses in the surrounding tissue, especially of the rectum eriproctitis). The remaining mucous membrane is swollen and in a ite of catarrh. The intestinal wall is irregularly drawn in and herent to the surrounding parts.

In some cases a tendency to **Healing** manifests itself. If the attack s been slight and the ulceration only superficial, there may be a mplete restoration of the mucous membrane, with insignificant atrices. But for the most part the cicatrices are of considerable superficial extent, perhaps surrounding the gut. The cicatrices of dysentery have usually a dark, almost a black colour. When they in the usual fashion contract, they cause narrowing of the intestine, and this, in some cases, is very considerable. Alternating with the narrowing there is very commonly dilatation of the more healthy parts, so that a very remarkable pouching of the colon may result, the narrowed parts being probably adherent to the tissues around. The obstruction produced in this way is all the greater because the contraction often throws the remaining mucous membrane into folds which may act as valves to the constricted parts.

The symptoms of dysentery often continue, in the chronic form, after healing of all the ulcers has occurred. In that case along with the cicatricial contraction mentioned above, there is a very marked atrophy of the coats of the intestine, so that the wall is very thin and translucent. There is also considerable adhesion to surrounding parts.

2. **Cholera.**—In addition to the epidemic disease known as **Asiatic cholera**, there is a condition known as **Cholera nostras**. The researches of Koch have demonstrated the connection between Asiatic cholera and the spirillum of cholera. It is probable that cholera nostras and choleraic diarrhœa may be produced by microbes of allied, but not identical characters.

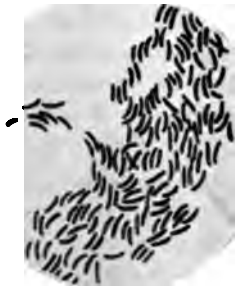


Fig. 594.—Cholera spirillum, from a culture. × about 1000.

Cholera spirillum, Vibrio Choleræ, Koch's comma bacillus.—This is a short, thickish organism, about two-thirds the length of the tubercle bacillus and somewhat broader (see Fig. 594). It is curved on its long axis so as to resemble a comma (but without the head of the printed comma). Sometimes there are two, end to end, with their curves in opposite directions, so as to resemble the letter S. They sometimes grow into longer spiral threads.

The spirillum is very actively motile by means usually of a single cilium which is at one end. The spirilla are readily stained by watery solutions of the aniline dyes, but the best are weak solutions of carbol-fuchsin or Loeffler's methylene blue. They require longer exposure than usual, not less than ten minutes for cover-glass preparations and twenty-four hours for sections. The fluid may be heated. Gram's method is not available as the spirilla are decolorized.

Cultures in gelatin show very characteristic appearances. The growing spirilla liquefy the gelatin slowly, producing a small funnel-shaped cup, the apex of which is occupied by the growing organism in the form of a granular whitish sediment. They also grow on potato, in milk, and even in water. They were found by Koch abundantly in the water of a tank in India. The presence of the cholera spirillum may be determined by a chemical colour test. Cultures made on media containing peptones (such as a simple 1 per cent. watery solution of peptone to which 1 per cent. NaCl has been added), give with chemically pure hydrochloric or sulphuric acid a red colour of varying intensity—the so-called **Cholera red.** This is due to the presence of nitroso-indol, a body formed by the addition of sulphuric acid to a mixture of indol and a nitrite—these latter substances being formed by the cholera organism during its growth. Other comma bacilli and the Vibrio Metchnikovi give similar reactions.

Cholera does not occur in animals, but Koch succeeded by a special method in inducing the spirilla to grow in the intestinal canal of guinea-pigs. He overcame the acidity of the stomach by an alkaline carbonate, and at the same time controlled the peristaltic action of the intestine by opium, and then found that cultures introduced into the stomach survived and propagated. The animal died in about two days, and the intestine was found to contain large quantities of fluid fæces which teemed with spirilla. An accidental contamination of one of Koch's pupils during a course of bacteriology resulted in an attack of cholera, thus affording a proof of the identity of the microbe. More recent experiments have amplified Koch's view.

In cases of Asiatic cholera Koch has always found the spirilla in the rice-water evacuations and intestinal contents. The mucous membrane of the intestine is red and swollen, especially in the region above the ileo-cœcal valve. The spirilla are present not only in the contents, but in the tubular glands, sometimes penetrating between the epithelium and the basement membrane. The organism does not penetrate beyond the intestine, but it apparently produces an active toxin, which irritates the intestine and, being absorbed, leads to weakening of the heart, lowering of the temperature, muscular cramps, etc.

If cholera organisms be introduced into the peritoneal cavity of an animal in which a high degree of immunity against cholera has been previously induced, their motility is impaired or lost, and they become gathered into little clumps, which after a short time disappear in the peritoneal fluid. This phenomenon, which constitutes **Pfeiffer's Reaction**, takes place outside of the animal body and may serve the purpose either of distinguishing the cholera organism from others resembling it, or of indicating the presence of "anti-microbic" substances in a special serum. A close analogy is offered by the bacillus of typhoid fever in which the reaction, applied in this latter sense, is used as a means of diagnosis.

A **protective vaccine** has been devised by M. Haffkine. An exalted virus is made by passing the spirillum through the peritoneal cavity of the guinea-pig a number of times in succession with intermediate culture. This virulent form is injected subcutaneously. As the organism does not survive in the subcutaneous tissue the cultures themselves may be injected, but it is safer to use carbolized cultures which can be preserved in sealed tubes for use. The injection of the strong vaccine is preceded by the use of a weakened form.

The spirillum is destroyed by drying, and is apparently transmitted by means of water, milk, etc.

The phenomena of cholera are those of a very violent irritation of the mucous membrane of the intestine; the symptoms of cholera are largely those of a general poisoning of the system. During life the disease is characterized by the discharge of extremely fluid stools which, from the intermixture of finely divided material, give the characteristic **Rice-water appearance**. Sometimes a patient dies without the bowels having been moved, and in that case the latter are found distended with the rice-water discharge. The flakes which give their character to the rice-water evacuations are not so much composed of desquamated epithelium as of little masses of mucus containing leucocytes. After death the epithelium may be found loose in the intestine, but this appears to be from post-mortem maceration, for, if examined sufficiently early, the epithelium is found apparently normal.

It is obvious that there is here an enormous transudation from the vessels of the intestine. The chemical character of the discharge, however, seems to indicate that it is not a mere inflammatory exudation from the vessels, but rather a secretion from the glands. Its specific gravity is low, 1006 to 1013. There is very little albumen present, and the discharge contains a ferment which has the power of converting starch into sugar.

The most marked post-mortem appearance is a remarkably rosy injection of the vessels in all the coats of the intestine, so that a red appearance is visible even in the serous coat whenever the body is opened. The mucous membrane is swollen and the closed follicles prominent. Occasionally there is a decidedly inflammatory condition present, which may be even of a dysenteric character.

The condition of the other parts of the body is directly referable to the enormous withdrawal of water from the blood. The blood itself is thick, dark, and imperfectly coagulated. The skin, serous membranes, and all the soft tissues are shrunk, dry, and parchment-like. The membranes of the brain are frequently injected. The kidneys present the characters of a slight parenchymatous inflammation.

3. **Typhoid fever.**—This disease is also due to the action of a microbe, and is characterized by a lesion in the intestine. The morbid poison finds entrance by the intestine, and produces irritation of the follicles and in its further passage of the mesenteric glands.

Bacillus typhosus. Typhoid bacilli are small rods with rounded ends (see Fig. 595) which are usually single or in pairs in the tissues, but may grow into longer threads. They possess very active motility, produced by means of numerous flagella, which are situated not only at the ends but on the sides of the bacilli. Spore-formation has not been conclusively demonstrated. The bacilli grow on various nutrient media. They form on fresh acid potato a thin layer, which to the naked eye only differs from the remainder of the surface in presenting a moister appearance. A small portion of the growth, however, when examined under the microscope, presents vast numbers of the active bacteria. This growth on potato is very characteristic, and, occurring as it does at the ordinary temperature, is very important as showing that these bacteria are not obligate parasites, but that they can grow outside the body. It has also been shown that they grow vigorously in milk (Wolffhügel), and that they may be preserved and even grow in water.

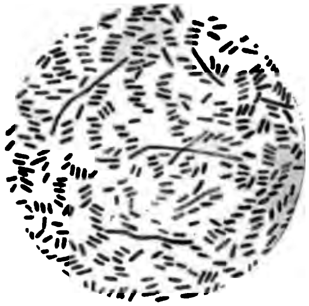


Fig. 595.—Bacillus of typhoid fever. × about 1000.

The typhoid bacillus stains with difficulty, giving only a faint colour with watery solutions of ordinary aniline dyes. With Loeffler's alkaline methylene-blue, and with Ziehl's carbol-fuchsin solution, they are readily stained. Sections should be left twenty-four hours in the solutions.

The bacilli apart from the toxins have not been unequivocally inoculated in animals.

In man the bacilli have been found in the intestinal contents, in the closed follicles of the intestines, the lymphatic glands, and the spleen. They have been found also in the blood of typhoid patients. In the tissues mentioned they grow in little masses with intervals between. They are not found in every case, diminishing apparently as the disease advances. Hence they are only uniformly met with in recent cases, in which numerous clumps of bacilli are found in the swollen Peyer's patches and glands. In later cases, where ulceration has occurred, they may be found in the deeper layers of the patches, in the mucous membrane, and muscular coat beneath the ulcer. According to Wright and Semple the typhoid bacilli are present in the urine in most cases of typhoid fever, and they are frequently absent from the stools. Sometimes the urine is actually turbid with typhoid bacilli. This seriously raises the question whether the intestine is really the main seat of the bacillus.

As the bacilli extend to the blood, it may be that the general symptoms of typhoid fever are due to this; but, as the extension is apparently not great, it is more probable that the bacilli form a poison in the intestine, glands, and spleen, which reaching the blood, produces these symptoms.

The propagation of typhoid fever occurs by multiplication of the bacilli outside the body and their subsequent ingestion. The fæces and urine we have seen may contain large numbers of bacilli. Considering how readily they propagate in milk and other media outside the body, it is not difficult to understand why they should frequently infect the ingesta and produce the disease in man. There are many epidemics which have been traced to contaminated milk.

The **Affection in the intestine** consists of an inflammatory swelling of the closed follicles and of the mucous membrane in their neighbourhood, the inflammation often going on to necrosis and sloughing. The disease has usually its point of greatest intensity at the lower extremity of the ileum, and it is often possible to see various stages of the process in proceeding from above downwards through the small intestine till it culminates close to the ileo-cæcal valve.

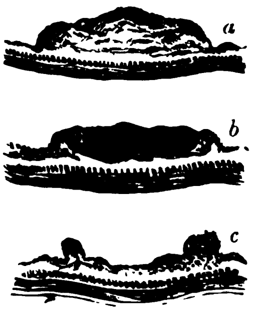


Fig. 596.—Diagrammatic representation of Peyer's patches in typhoid fever. *a*, early stage with swelling of the patch; *b*, later stage with sloughing; *c*, ulcer with infiltrated walls. (THIERFELDER.)

In the normal state, especially in the adult, the Peyer's patches and the solitary follicles are very slightly prominent. The patch viewed from the surface shows a congeries of shallow depressions separated by slightly elevated ridges, which run in from the general mucous membrane, and form a kind of network. It is in the depressions that the follicles are placed. In typhoid fever there is at first a general swelling of the patch; it is an inflammatory swelling accompanied by abundant infiltration of round cells which occupy both the closed follicles and the mucous membrane. The patch is obviously raised and its margins are somewhat abrupt (Fig. 596, *a*). Viewed from the surface there is at this early stage simply an exaggeration of the normal appearance. The ridges of mucous membrane are swollen so that the depressions are more hidden, and an appearance is produced which has been compared to that of the convolutions of the brain in miniature. The swollen patch has a pinkish or whitish colour. At the same time the solitary follicles show themselves as elevations at intervals.

As the time goes on the whole tissue becomes more and more infiltrated with round cells (Fig. 597), and the raised patch more solid and its surface more homogeneous. The invasion of round cells extends to the submucous and muscular coats, even to the serous, and passes to some extent beyond the patch. A similar condition occurs in the solitary follicles; they also present a marked increase in size, and are less defined, by reason of the infiltration around them.

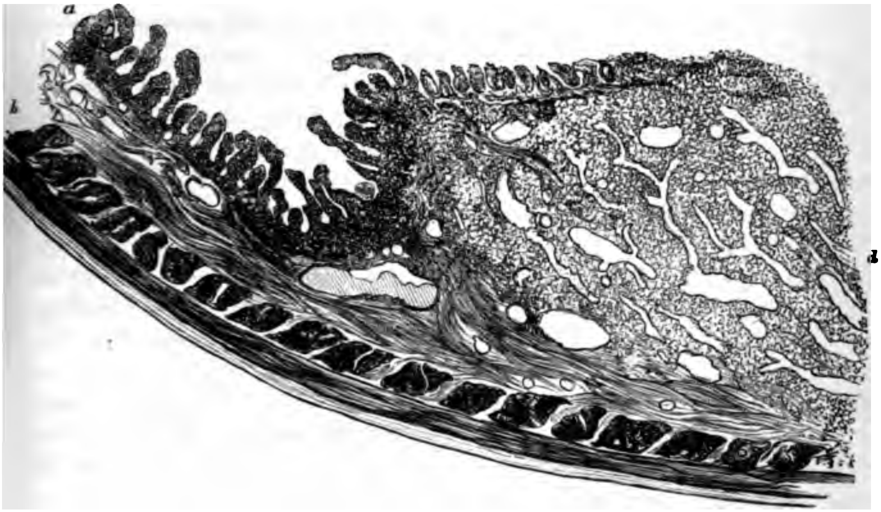


Fig. 597.—Portion of a Peyer's patch in an early period of typhoid fever. *a*, mucous membrane which becomes raised when the swollen patch is reached; *b*, internal layer, and *c*, external layer of muscular coat; *d*, swollen patch composed of round cells with dilated blood-vessels. At the right of the section the round cells are invading the submucous tissue and approaching the muscular coat. × 16.

On this condition follows **Necrosis** (Fig. 596, *b*). The infiltrated and altered patch or solitary follicle forms a slough, of larger or smaller size, which remains adherent for a time, and like all sloughs in the intestine becomes brown or yellow owing to staining by the biliary colouring matter, which stains dead tissue, but leaves unaffected living structures. Generally there is a single slough on a Peyer's patch, not involving the whole patch, but nevertheless of considerable superficial extent (see figure). Sometimes there are several sloughs corresponding to some of the closed follicles of which the patch is made up.

After a time the slough separates and an **Ulcer** is left with infiltrated base and margins (Fig. 596, *c*). The ulcers are confined to the patches and solitary follicles, so that they repeat their shape and locality. The walls are succulent and vascular, and considerable hæmorrhage may occur from them. The ulceration may extend more deeply than the mucous membrane, involving a necrosis of the muscular and even of the serous coat, so that **Perforation** may result. Perforation may occur in one of two ways. In the first place an ulcer may extend in depth till it penetrates through the muscular and serous coats. In this case the process is somewhat gradual, and there is generally an inflammation of the peritoneum sufficient to cause adhesion and prevent the intestinal contents passing into the abdominal cavity. In the second place, perforation may occur in a manner comparable to the perforation of the pleura in phthisis pulmonalis which leads to pneumothorax. The serous coat is undermined by the ulcer, and as its nutrition is cut off it undergoes necrosis. In such cases the brown slough may be visible on viewing the intestine externally. A partial separation of the slough may allow of perforation, and as this form is more acute and not so likely to be accompanied by considerable adhesions, the contents of the intestine are more apt to escape into the peritoneal cavity and produce fatal peritonitis.

When **Recovery** takes place from the fever, the lesion in the intestine retrogrades. The exact process of resolution varies according to the stage reached. If, in any part, ulceration has not yet occurred, there is a gradual diminution of the patch and a return to the normal. If ulceration exists the ulcer fills up and cicatrizes. The **Cicatrix**, however, remains a long time, often of a slaty colour, and unusually presents much puckering. It may indeed be a flat cicatrix in which the intestinal wall is merely thin and transparent. This is shown in Fig. 598, which represents the condition in the case of a girl who died of pneumonia a year after having passed through an attack of typhoid fever.

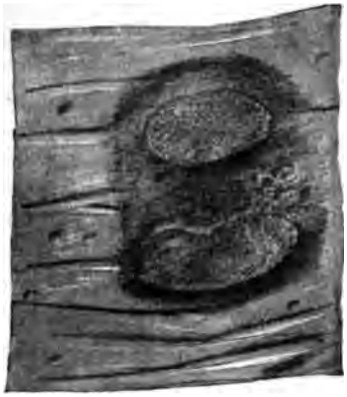


Fig. 598.—Cicatrices on a Peyer's patch from typhoid fever.

The **Lymphatic glands** of the mesentery enlarge, and present on section a red injected appearance and soft consistence. There may be necrosis here also, giving rise to an opaque greyish condition in the midst of the gland. When recovery takes place the glands return to the normal, and the sloughs are usually absorbed, although they may become caseous and subsequently calcareous.

It is to be remembered also that the **Spleen** is enlarged, and there is here more than in typhus fever a swelling of the Malpighian follicles—which are lymphatic in structure—and so the spleen is firmer and paler on section than normal (see p. 600). The specific microbe is also present in the spleen.

4. **Anthrax** (*Mycosis of the intestine*).—The wall of the intestine is sometimes attacked by the anthrax bacillus. Several cases described as mycosis intestinalis belong to this group, although the name has also been used for other affections, such as septic inflammations and actinomycosis. The intestine may be the place of entrance of the bacilli, and the lesion will then be the primary one. On the other hand, the intestinal lesion may simply be part of the general infection, and concurrent with affections of other organs.

The lesion presents itself in patches situated most frequently in the small intestine, but also in the stomach and colon. The patches are œdematous and infiltrated with blood, and there is generally a considerable dark slough on the prominences of the folds. The characteristic bacilli are found in the œdematous fluid and in the blood-vessels and lymphatics. The lymphatic glands are swollen, and infiltrated with blood. The bacilli are sometimes present in them in very large numbers.

Cases of this kind have mostly occurred amongst workmen who have handled the hides of animals affected with anthrax. Probably the bacilli are allowed to contaminate the food, and so reach the intestine.

5. **Actinomycosis**.—The intestine is occasionally the primary seat of actinomycosis. In a case recorded by Chiari the mucous membrane of the large intestine was the seat of raised whitish patches, in which the yellow granules of the parasite were visible. The mucous membrane around was swollen and red and covered with tough mucus. The vermiform appendix has been the seat of this disease in some cases.

Literature.—*Dysentery*—Annesley, Diseases of India, 3rd ed., 1855; Virchow, Virch. Arch., v. and lii.; Heubner, in Ziemssen's Cycl., i., 1875; Ziegler, Lehrb., ii.; Maclean, in Reynolds' Syst. of Med., i., 1866; Baly, Path. and treatment of dysentery, 1847; Fagge, Medicine, ii.; Woodward, Med. and surg. hist. of war of rebellion, part ii., vol. i., 1879; Flexner, Philadelphia Med. Journ., vi., 1900. *Cholera*—Goodeve, in Reynolds' Syst. of Med., i., 1866; Lewis and Cunningham, Cholera, 1878; Report of cholera conference at Berlin, 1885, Brit. Med. Jour., 1885, i., 1011 and 1075, also separate Report of Conference; Macnamara, Hist. of Asiatic cholera, 1876; Wood, Reports, Lab. Roy. Coll. Physicians, Edin., ii., 1890.

Typhoid Fever—Liebermeister, in Ziemssen's Cyclop., i., 1875; Murchison, Continued fevers, 2nd ed., 1873; Marchand, Centralbl. f. allgem. Pathol., i., 1890; Cygnäus, Ziegler's Beiträge, vii., 1890; Herdman and Boyce, Oysters and disease, 1903. *Anthrax*—Bollinger, in Ziemssen's Cycl., iii., 1875; Vierhuff, Anthrax intest., 1885; Waldeyer, Virch. Arch., iii.; Poland, Path. Trans., xxxvii., 1886. *Actinomycosis*—Zemann, Wien med. Jahrb., iv., 1883; Chiari, Prag. med. Wochenschr., 1884; Leith, Edin. Hosp. Reports, ii., 1894.

VIII.—TUBERCULOSIS AND SYPHILIS OF THE INTESTINE.

1. Tuberculosis.—In the great majority of cases this condition is secondary to pulmonary phthisis, and it occurs in about two thirds of the cases of that disease examined after death. It is to be accounted for by the sputa being partly swallowed, and the virus applying itself to the intestine directly.

There seems little doubt also that tuberculosis of the intestine may be induced by the tubercle bacilli being present in the food. Experiments in animals show that this mode of infection is possible. The bacilli, however, may be absorbed by the intestine without inducing tuberculosis of it. The mesenteric glands may become tubercular, without any affection of the intestine. This result of experiment in animals is confirmed by observation in man.

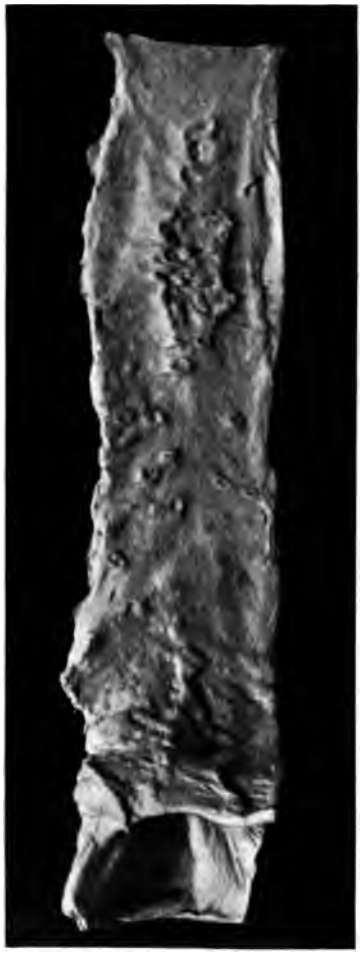


Fig. 599.—Tubercular ulceration of the lower end of the ileum involving Peyer's patches and the solitary follicles.

The bacillus attacks the same structures as does the bacillus of typhoid fever, namely, the closed follicles and Peyer's patches (Fig. 599), and at first it produces a change of a somewhat similar kind. There is an enlargement of the closed follicles by reason of a great new-formation of cells which infiltrate the neighbouring mucous ıbrane as well as the follicles. This primary enlargement is, ever, much less uniform than in typhoid fever. On the whole, greatest towards the lower part of the ileum, but it presents t irregularities. Even in the Peyer's patch it generally affects w closed follicles, and not the whole, so that there are rounded ninences dotted over the patch. Moreover, it is not simply an mmatory infiltration which occurs; there are tubercles present ı the first.

he enlarged follicles undergo caseous necrosis, so that very soon are seen to have an opaque yellow kernel, while the epithelium

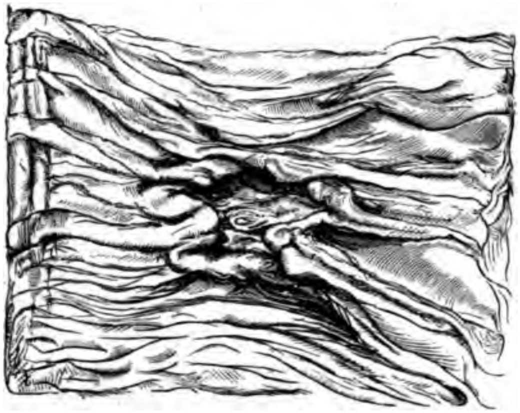


Fig. 600.—Tubercular ulcer of the intestine. The swollen overhanging edges are indicated.

covers them. In the next place softening occurs, and the caseous ; is discharged, leaving a crater-shaped ulcer. The ulcer advances continues to have overhanging edges, which are infiltrated with ocytes and contain miliary tubercles (see Figs. 600 and 601). re may be at first several such ulcers in a Peyer's patch, and other ary ones in other parts. They extend by fresh infiltration of the hbourhood and fresh necrosis, while at the same time miliary rcles are visible in the midst of the inflammatory infiltration. The ration very commonly involves the muscular coat, and even the ıs, and tubercles are often to be seen almost free of inflammatory ration at a distance from the ulcers in the midst of the muscular or even in the peritoneum (see Fig. 601, *d*).

he ulcer itself extends, as a rule, much more laterally than deeply, in its extension it does not respect the boundaries of the Peyer's hes or solitary follicles, but passes beyond them, generally advanc- more across the gut than longitudinally. In this way ulcers are, not infrequently, much elongated in a direction transverse to the intestine, and may even form a ring around it. The ulcers have usually their centres at the part of the gut opposite the mesenteric attachment, as the Peyer's patches, in which they begin, have their seats there.

The position of the ulcers is often indicated before opening the intestine by the appearance of the peritoneal surface. If the ulcer be of any considerable size there is some inflammation of the peritoneum, evidenced by redness and, very often, by elongated projections of vascular connective tissue. But above all we can generally see in the peritoneum groups of little white nodules, which are tubercles in or under the serous coat. The existence of these tubercles is sometimes even useful in determining whether an ulcer is a tubercular one or not. It is rare that the ulcer penetrates through the peritoneal coat, and, if it does, it is usually protected by adhesion to neighbouring loops of intestine.

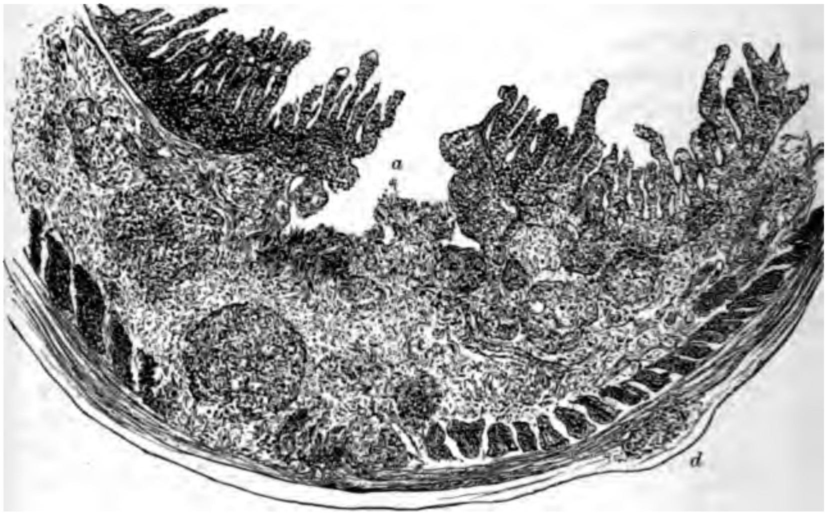


Fig. 601.—Section of a small tubercular ulcer. In the middle there is a crater-shaped ulcer (*a*) with overhanging edges. The mucous membrane around is infiltrated with round cells in the midst of which a few tubercles are indicated. Beneath the ulcer the muscular coat is infiltrated. At *d* there is a small sub-serous tubercle. × 16.

As a general rule the tubercular ulceration is most marked in the ileum, but not infrequently the colon is attacked, and there may be ulcers of very large size there. The Vermiform appendix is not a very infrequent seat of ulceration.

The process is for the most part a chronic one, and the ulcers advance slowly. Sometimes, however, and usually in connection with acute phthisis, there is a rapid swelling of the follicles, and ulceration occurs softening, without preliminary caseous necrosis. In these cases rforation is much more liable to occur.

As amyloid degeneration is a frequent accompaniment of phthisis, it ay coincide with tubercular ulceration in the intestine.

2. **Syphilis.**—The rectum is liable to be invaded by syphilitic lesions tending from the anus and perinæum, especially in women. Besides is there is sometimes a more independent syphilitic affection of the ctum leading to stricture. There are the usual gummatous infiltra- ons with ulceration, and these by partial cicatrization may lead to ntraction. The infiltration may affect the tissues outside the intes- ne. A few cases have been observed in new-born children.

Literature.—*Tuberculosis*—Spillmann, Tuberc. du tube digestif (with literature), 78; Orth, Lehrb. d. path. Anat., 830; Baumgarten, Zeitschr. f. klin. Med., 1885, d Tuberculose, 1885; Grawitz (Peritonitis), Charité-Ann., 1886. *Syphilis*—acek (with literature), Vierteljahrschr. f. Dermat. und Syph., x., 1883; Förster, hrb. d. path. Anat., ii., 148; Klebs, Handb. d. path. Anat., i., 261; Lang, orles. über Syph., 2nd. ed.; Israel, Charité-Ann., ix., 1884; Norman Moore, Hutchinson, Syphilis, 1887, p. 256; Birch-Hirschfeld, Lehrb., ii., 1894; ayem et Tissier, Revue de Méd., ix., 1889; Rieder, Jahrb. d. Hamburg. rankenanst, 1890; Homén, Centralbl. f. allgem. Path., 1893.

IX.—RETROGRADE CHANGES AND ABNORMAL CONTENTS.

Atrophy of the mucous membrane of the intestine is an occasional onsequence of inflammations, catarrhal, dysenteric, and other. There ave also been described atrophic and degenerative changes in the testinal nerves in acute fevers and in acute affections of the central ervous system. The changes in the nerves are accompanied by changes the muscle.

Amyloid degeneration is the most frequent retrograde change in the testine. It affects the arteries and capillaries of the mucosa and sub- ucosa, and especially the vessels of the villi, but it often extends to e whole tissue of the villi except the epithelium, and to the muscular undles of the submucosa. To the naked eye the intestine frequently ppears pale and smooth, but the condition is best detected by the ldition of iodine solution. The affected villi then appear as deeply ained granules, while the closed follicles and Peyer's patches are naffected. If ulcers be present, as is not infrequently the case, they so are unaffected and show a contrast in colour. The villi are fre- uently extensively lost in amyloid disease, but this may be a post- ortem effect, the brittle amyloid structures being broken off in andling the intestine.

Necrosis, which here sometimes assumes the characters of **Gangrene**, ccurs, as mentioned above, in various conditions—infarction, dysentery, hernia. It also results occasionally from continued pressure by hard contents. This is most common in the vermiform appendix, but also occurs in the colon and rectum from hard fæces. The result is the formation of ulcers. Gangrene may also result from traumatic separation of the mesentery, when this occurs close to the intestine.

Foreign bodies in the intestine. Intestinal concretions.—These mostly consist of the ordinary contents dried-in and impregnated with lime salts. The concretions have a kernel composed usually of dried fæces, but sometimes a gall stone, a fruit-seed, or a mass of hairs, forms the kernel. The central parts so formed are coated with phosphate and carbonate of lime. Concretions are very common in animals, especially in the horse, in which they have been found weighing 20 pounds. They are composed of the husks of corn mixed with hairs which the animals have licked from their bodies and swallowed. These are felted together and compacted into large balls.

Intestinal Sand (*Sable intestinal*).—Sand-like particles, often resembling uric acid microscopically, are not infrequently met with in the motions, especially in cases of mucous enteritis. The substance consists mainly of phosphate and carbonate of lime with some colouring matter the precise nature of which is not known.

Intestinal concretions occur chiefly in the cæcum and vermiform appendix, where they may give rise to ulceration and perforation. (See above, Typhlitis and Perityphlitis.)

Gall-stones also occur as foreign bodies in the intestine, and sometimes they are large enough to cause obstruction at the ileo-cæcal valve or elsewhere.

Parasites in the intestine.—Vegetable parasites are of little consequence if we except those considered in previous paragraphs.

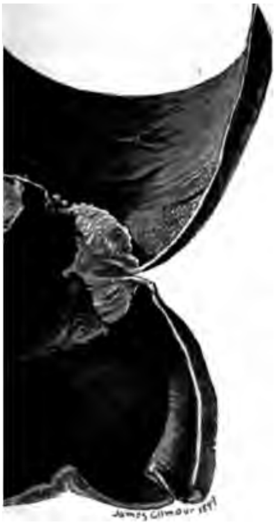
Animal parasites have been described in the general section on parasites. They comprise chiefly the tape-worms, the ascarides, the oxyuris, the trichocephalus dispar, and the ankylostomum duodenale.

Literature.—NOTHNAGEL, loc. cit.; SCHEIMPFLUG, Zeitschr. f. klin. Med., ix., 1885; FURNEAUX-JORDAN (Fatty change and failure of muscular wall as cause of obstruction), Brit. Med. Jour., 1879, i., 621; WAGNER, Arch. d. Heilk., 1861; KYBER (Amyloid), Virch. Arch., lxxxi., 1880; EDINGER (Amyloid dis. and dilat. of colon), D. Arch. f. klin. Med., 1881; ZESAS (Separation of mesentery), Arch. f. klin. Chir., 1886; SCHUBERG (Concretions), Virch. Arch., xc., 1882; LABOULBÈNE, Arch. gén. de méd., xxii., 1873; FRIEDBERGER und FRÖHNER, Lehrb. d. path. d. Hausthiere, 1885; LEUBE, in Ziemssen's Cyclop., vii., 1877; LABOULBÈNE (Intestinal Sand), Bull. Acad. de Méd., Paris, 1873; DELÉPINE, Trans. Path. Soc., Lond., xli., 1890; THOMSON and FERGUSON, Journ. of Path. and Bact., Feb., 1900; DUCKWORTH and GARROD, Medico-Chir. Trans., 1901; RITCHIE, Encycl. Med., xi., 1902.

X.—TUMOURS OF THE INTESTINE.

:y **cancer.**—This is by far the most frequent and important umour. Cancers are almost confined to the **Large intestine**; already connected this with the fact that this portion is most to the irritation of the stagnant fæces. This is the more ıs the most frequent localities are the **Rectum**, the **Flexures**, **Cæcum**. At the same time cancers are not unknown in the əstine.

mmonest form of cancer is a very **Chronic epithelioma** with ɜ masses of cylinder cells (Fig. 602 and Figs. 196-197, pp.



-Cancer of the intestine, with. ıd dragging-in of the wall.

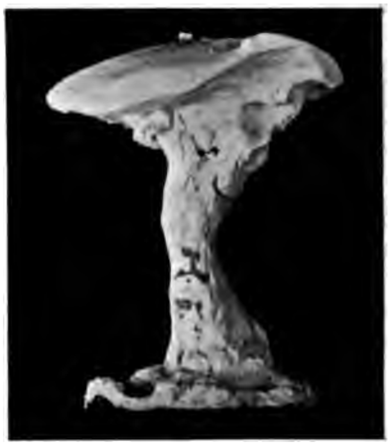


Fig. 603.—Plaster cast of the lumen of the large intestine in a case of cancer. (Dr. Gray.)

From the resemblance of these structures to the tubular ' the intestine, and from the fact that evidently the tumour s from these glands, the name **Adenoid tumour** or **Malignant** is frequently used, just as in the case of the stomach. umour is frequently ring-shaped, and as ulceration readily ıere may be little more than an ulcer with infiltrated edges. **ıction of the intestine** is a frequent result of cancer. This is he most part to the ulceration and subsequent contraction in əss of partial healing. There may be, as in Fig. 602, great -in of the intestinal wall or other deformity in consequence ırinking. The occlusion of the calibre may be completed by ıt folding of the mucous membrane as a result of the irregular contraction. In most cases the symptoms of obstruction are of gradual onset, but there are not a few cases in which a sudden and complete obstruction has been the first evidence of any lesion of the intestine. Fig. 603 demonstrates in a striking manner the marked narrowing of the lumen of the bowel which so frequently occurs.

On microscopic examination the cancerous structure is usually quite obvious, but in some cases it is to a large extent destroyed by ulceration. At the edges, however, we may distinguish masses of epithelial cells with a glandular arrangement, and in the adhesions around the affected part of the intestine and at further distances glands enlarged with cancerous tissue may be found.

Next to the cylinder-celled epithelioma the most common form is **Colloid cancer**. This forms a much more prominent tumour, which may involve a considerable length of the gut, and incorporate the entire coats. This form may produce obstruction by its mere bulk, although it also is liable to ulceration, and the consequent contraction of the gut added to the bulk of the tumour frequently effects obstruction. It does not so readily affect the lymphatic glands, but more usually extends through the wall into the peritoneum.

Soft cancer is much less common here than in the stomach, and it resembles the same form of tumour there. It extends to the lymphatic glands and frequently also to the liver.

Other tumours.—The remaining tumours of the intestine are of less importance. **Fibromas** (Fig. 108, p. 282), **Lipomas** (Fig. 116, p. 289), and **Myomas** (Figs. 129-130, pp. 301-302) occur, and are all apt to pass into the interior of the intestine and assume the form of **Submucous polypi**. These polypoid growths by being dragged on in the peristaltic movements of the intestine may produce invagination (Fig. 108, p. 282). **Mucous polypi** have been already mentioned as occurring, especially in the rectum, in catarrh. **Sarcoma** is not uncommon in the small and large intestine. Round-celled and spindle-celled (Fig. 176, p. 339) varieties are found. In the rectum the melanotic form has repeatedly been observed (see Fig. 604).

A peculiar form of tumour is the **Cyst of the vermiform appendix**. In some cases of obstruction of the aperture the appendage becomes distended with mucous and may assume large dimensions, as in Fig. 605. The contents may remain mucous in character or become serous.

Lymphoma is not infrequent as a form of secondary new-formation in the intestine. A general enlargement of the closed follicles occurs sometimes in leukæmia and in Hodgkin's disease, and it may be so considerable as to give the appearance of numerous prominent tumours projecting from the surface.

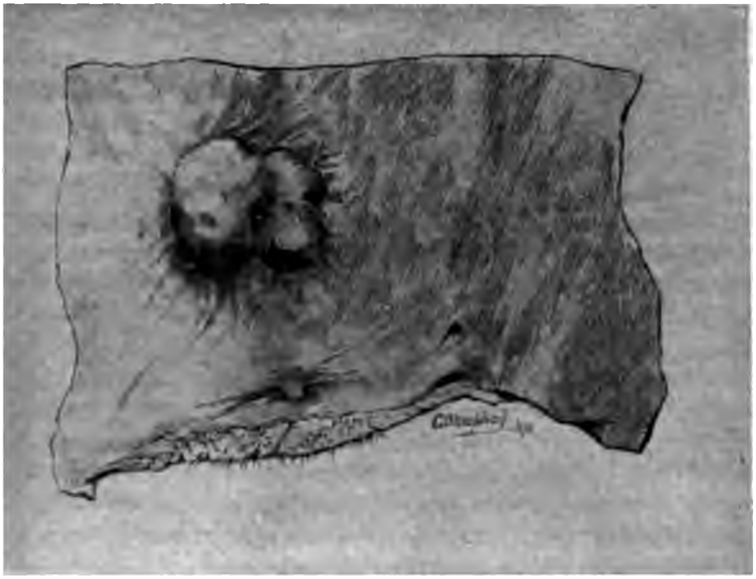


Fig. 604.--Melanotic sarcoma of the rectum.

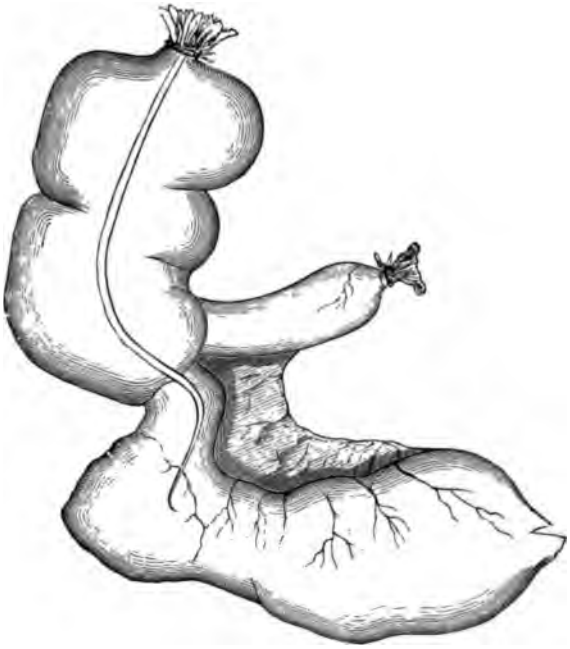


Fig. 605.—Cyst of vermiform appendix. The appendix is converted into a bulky cyst which was filled with gelatinous material.

There is, however, sometimes a more definite tumour-formation in **Lympho-sarcoma,** when the primary lesion is localized in the mesenteric and intestinal lymphatic structures. There may be extensive tracts of the intestine infiltrated with lymphatic tissue which may replace the mucous membrane and the other coats, so that sometimes the enlarged intestinal tube is converted into a soft white structure composed of lymphatic gland tissue (see under Lympho-sarcoma).

Literature.—Klebs, Handb., i., 1869; Cripps (numerous illustrations), Path. Trans., 1881, xxxii., 87; Haack, Arch. f. klin. Chir., xxix., 1882; Weigert (Secondary cancer), Virch. Arch., 1876, lxvii., 513; Carrington (Hodgkin's dis., with references to literature), Path. Trans., xxxv., 385. Literature of other forms of tumour in Orth, Lehrb. der path. Anat., 1877, p. 855; Coats (Cysts of vermiform), Brit. Med. Jour., 1875, i.; Struthers (Varieties of appendix and cæcum), Edin. Med. Jour., 1893; Smoler (Sarcoma), Prag. Med. Woch., 1878; Libman, Amer. Journ. Med. Sciences, cxx., 1900; Wiener, Ziegler's Beiträge, xxv., 1899; Péraire (Fibroma), Rev. de Chir., 1900.

XI.—OBSTRUCTION TO THE CALIBRE OF THE INTESTINE.

This condition has been incidentally mentioned as occasioned by several of the lesions already described. It may be well here to sum up the various forms of intestinal obstruction and to describe the effects produced when the calibre of the intestine is interrupted.

Causes of obstruction.—Next to hernia, the most frequent cause of obstruction is the contraction of cicatrices resulting from ulceration, and in the great majority of cases the ulcers are malignant, that is to say, they arise by the breaking down of cancers. It is to be remembered that in contractions of the calibre such as these the direct cause of the final obstruction may be the folding of the mucous membrane above the stricture, this acting like a valve to the narrowed part. Tumours also obstruct sometimes by their bulk. Similarly gall-stones, masses of fæces, collections of round worms, may occlude the calibre. Invagination is the commonest cause in children. There is also twisting or torsion. Lastly, we have obstruction by incarceration, the intestine passing into a position where a loop is caught at the neck and strangled. Hernias form the commonest examples of this kind, but there are a number of cases in which the intestine slips under a bridge or ligament, and becomes, as it were, pinioned and compressed. These latter merit further consideration.

Obstruction by a bridle or ligament occurs so obviously to the mind that its frequency is apt to be overrated. In reality it forms a small proportion of the entire cases. The abnormal band may be formed by the adhesion of normal or other structure to various parts of the omen so as to form bridges. Thus the vermiform appendix may ere by its tip and form a bridge; or a Meckel's diverticulum similarly adhere; or the omentum may be tied down in such ay as to form a narrow bridle. But sometimes the band is itself inctly of new formation. Thus there has been a local peritonitis, and opposing surfaces may become adherent in the usual way of inflamory adhesion, by vascular connective tissue; or by the movements of intestine the connective tissue may be dragged upon and elongated it forms a band or ligament, which may afterwards tie down a loop

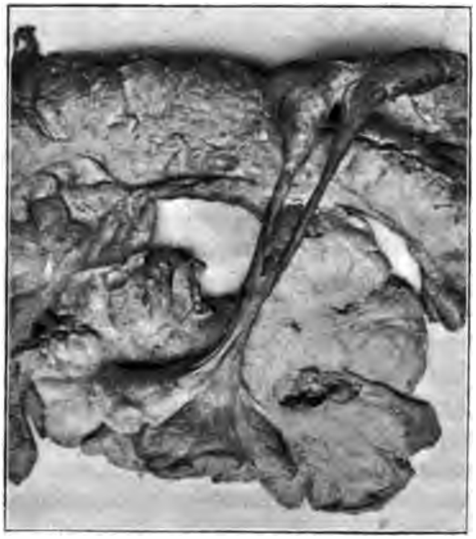


Fig. 606.—Intestinal band.

ntestine. The formation of such bands is mostly the result of rcular peritonitis which has undergone healing, recovery from this se being more frequent than is usually supposed (Fig. 606).

ery unusual form of incarceration is that in which there is an **Aperture in the ntery** through which the intestine passes. This may be produced by a tear in esentery. In a case observed by the author there was a large round gap five inches in diameter with rounded edges, and obviously of long standing, ps congenital. The greater part of the small intestine had become impacted omplicated fashion into the aperture, and obstruction had finally resulted.

esults of obstruction.—The most direct effect is an accumulation e intestinal contents in the parts of the intestine above the seat of ruction. This may so greatly distend the intestine that its muscular is paralyzed by the internal pressure. The stagnating fæces mpose—the decomposition being more rapid and complete and absorption more considerable in the case of fluid fæces. As a result of the decomposition the contents of the small intestine may acquire the characters of those of the large. This decomposition of the intestinal contents leads to several important results. In the first place there may be great formation of gas which still further distends the bowel and may produce the condition of exaggerated inflation called **Meteorism**. A return of the fæces in the reverse direction may occur, and if the decomposition is sufficiently advanced there may be vomiting of matter having a fæcal character. This alarming phenomenon of **Stercoraceous vomiting** is sometimes referred to a reverse current extending from the colon. We can hardly suppose, however, that the fæces are able to pass the ileo-cæcal valve, and for the most part the vomited matters are really the stagnant contents of the small intestine which have undergone fæcal decomposition. Of course there is a reverse current, else the intestinal contents would not reach the stomach. But this does not necessarily imply a vermicular movement in the reverse direction. If the intestine is distended, and is interrupted at a particular point, then the vermicular movement in the usual direction will carry the external layer of contents downwards to the point of obstruction. In order to accommodate this fresh arrival there must be a return current upwards, in the centre of the tube. There is a similar condition to what exists normally in the stomach where the contents are carried to the pylorus, and meeting the obstructing sphincter return for the most part down the centre of the cavity towards the fundus.

Again, the products of decomposition may be absorbed to an abnormal extent and appear in the urine. There are two substances resulting from the decomposition of albuminous matter which are normally present to a limited extent in the urine, namely, **Indican** and **Carbolic acid**. In cases of obstruction these substances, one or both, are increased in quantity sometimes to a very striking extent. This increase does not occur unless the stagnation extends to the small intestine where the albuminoids are present. It does not occur therefore in ordinary constipation which affects the large intestine alone, because the albuminoids are absorbed before they reach the large intestine.

Literature.—COHNHEIM, Allg. Path., ii., 147, 1882; JAFFÉ (Indican in urine), Virch. Arch., lxx., 72, 1877; SALKOWSKI, ibid., lxxiii., 409, 1878; BRIEGER, Zeitschr. f. klin. Med., iii.; TREVES, in Allbutt's Syst. of Med., iii., 1897.

SECTION VIII.

DISEASES OF THE LIVER, PANCREAS, AND PERITONEUM.

A.—**The Liver.** Introduction. Post-mortem changes. I. **Malformations and Deformities.** II. **Disorders of Circulation.** 1. Passive hyperæmia (nutmeg liver), 2. Thrombosis and Embolism. III. **Retrograde changes**, chiefly fatty infiltration, amyloid disease, and pigmentation; Icterus. IV. **Acute Yellow Atrophy.** V. **Hypertrophy and Regeneration.** VI. **Inflammations.** 1. Suppurative hepatitis, including tropical and pyæmic abscesses; also biliary abscess. 2. Chronic interstitial hepatitis, Cirrhosis; causation; lesions; effects. Biliary and hypertrophic cirrhosis. 3. Perihepatitis. VII. **Syphilis and Tuberculosis.** Syphilitic cirrhosis and gummata. Tuberculosis, chiefly secondary. VIII. **Tumours**, chiefly cancers; occasionally primary—chiefly secondary. Parasites, chiefly Echinococcus.

B.—**Bile-ducts and Gall-bladder.** 1. Gall-stones, single and multiple, 2. Obstruction of ducts, 3. Rupture and perforation, 4. Tumours.

C.—**Pancreas.** Malformations, hæmorrhages, inflammations, retrograde changes. Tumours, especially cancers. Concretions and obstructions of duct.

D.—**Peritoneum.** Introduction. 1. Malformations; 2. Disorders of circulation, chiefly hæmorrhage and ascites; chylous ascites and ascites adiposus; 3. Inflammations, septic, chronic; 4. Tuberculosis, tubercular peritonitis, healing and its results; 5. Tumours, including Retroperitoneal sarcoma.

E.—**Secondary Extension of Cancers of the Abdominal Organs.**

A.—THE LIVER.

INTRODUCTORY.—The liver is the largest gland in the body, its weight being on an average from 48 to 58 ounces in the adult male and 40 to 50 ounces in the female.

In its **Function** the liver is related to the intestinal canal and the blood. The formation of bile is probably the least of its functions, but as the bile pigment is derived from the hæmoglobin, there must be a destruction or removal of effete red blood-corpuscles in the liver. A more important function is the preparation of glycogen, whatever may be the uses to which this substance is put. The liver also seems to have important relations to the free fat of the body, and under certain circumstances stores it up in its substance (see Fatty Infiltration).

The functions of the liver being thus manifold and somewhat obscure, the effects of disease on it are difficult to disentangle. Many of the diseases cause atrophy of its proper tissue, but they nearly all at the same time affect either the body as a whole or the vascular arrangements of the abdomen which are so peculiarly related to the liver.

The **Circulation of the liver** is very peculiar and claims special attention, because most diseases of the organ produce important effects upon it. Most of the blood comes to the liver by **the Portal vein,** and the proper hepatic tissue is arranged in relation to the ultimate ramifications, and they are in immediate connection with the hepatic lobules. **The Hepatic lobule** is a group of hepatic cells with blood-vessels, measuring about the twentieth of an inch in diameter, and having in man a polygonal or somewhat globular shape. The interlobular vein lying outside the lobule sends capillaries into it, and these seeking the centre of the lobule open into the central or intralobular vein which is the radicle of the hepatic vein. Between the capillaries lie the hepatic cells, which are arranged in rows or cylinders radiating from the centre of the lobule like the capillaries. The stellate cells of Kupffer lie between the hepatic cells and the capillaries and seem to be intimately connected with both.

Blood is also brought to the liver by the **Hepatic artery** which supplies chiefly the connective tissue and walls of the blood-vessels. Its capillaries terminate in veins which open into the intralobular veins (according to Cohnheim and Litten), so that this blood also finds its way into the hepatic capillaries and on into the hepatic vein.

The **Connective tissue** of the liver is often described as if it formed a special covering to the portal vein, being called Glisson's capsule. It really forms a supporting stroma which holds the portal vein, the hepatic artery, and the hepatic duct, which all lie side by side. The lymphatic channels are also contained in it. In swine the connective tissue surrounds each lobule and defines it distinctly from its neighbour, but in man it stops short at the interlobular vein, and except where this vein is, the lobules at their margins merge into each other, and their capillaries are in communication. Examination of Fig. 609, p. 1019, and Fig. 221, p. 392, in which the lobules are demarcated by fatty infiltration, will show how they run into one another at their peripheries. Although no proper fibrillated connective tissue is present inside the lobules, yet a fine reticulum accompanies and supports the capillaries.

The circulation in the portal vein, and especially in the capillaries of the liver, must be unusually slow. The blood before it reaches the liver has passed through one set of capillaries, and here it passes through a second set; it has therefore lost very largely the force derived from the contractions of the heart. It is probably for this reason that the liver is so frequently the seat of secondary deposition as in tuberculosis, cancers, etc., and of the deposition of solid pigments. We may suppose that as the blood moves so slowly there will be time for any granular material to settle down and produce its special effects. We know that when vermilion is injected into the blood it is found largely in the liver. Similarly the pigment containing iron present in the blood in pernicious anæmia is found largely there.

The **Hepatic ducts** running in the connective tissue along with the portal vein and hepatic artery are lined with cylindrical epithelium. These are connected with the biliary capillaries, which originate inside the lobules and seem to be in part formed by the hepatic cells themselves, each cell having on its surface a groove which, with a corresponding groove in the cell opposed to it, forms a tube.

Post-mortem changes.—The liver is liable to local alterations in colour, in the form of pale anæmic areas, from the pressure of neighbouring structures, as the ribs, or distended loops of intestine. It frequently also assumes a blue colour from decomposition, especially where it is in contact with the transverse colon.

Gas is frequently formed in the tissues after death, but there are some cases in which the development of gas, especially **in the liver,** is so marked and extensive that special attention has been attracted to them. In the cases referred to the liver is found more or less honey-combed with cavities, produced in the substance of the organ by an evolution of gas in many centres. A similar evolution of gas occurs in the kidneys, spleen, in the subcutaneous tissues, and elsewhere, where it produces emphysema. A peculiar odour is exhaled by the affected organs. In such cases the organs have been found the seat of colonies of microbes, which comprise several species. One variety commonly found is a short bacillus with rounded ends which stains with the ordinary reagents and also by Gram's method. A capsule can often be demonstrated. To this the name of **Bacillus ærogenes capsulatus** has been given. It is present in the walls of the gas cavities and in the blood-vessels, being found in the case of the liver in the portal and hepatic branches and in the capillaries. The microbe may be cultivated in the ordinary media. It is anaërobic. It produces gas abundantly in cultures.

It is certain that the principal growth of this microbe is post-mortem, but its wide dispersion and abundance in the blood suggest that it may have been planted during life. Most of the cases in which the condition has been observed were septic, that is to say, there were external wounds. But there are cases—the author is cognizant of at least two—in which a rapidly fatal illness having the characters of toxæmia (so-called blood-poisoning), but without any external wound, have been associated with the condition under consideration, and with no other apparent cause for the symptoms. Similar cases have been recorded by other observers, and the bacillus phlegmones emphysematosæ of E. Fraenkel is now regarded as identical with this organism.

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I.—MALFORMATIONS AND DEFORMITIES OF THE LIVER.

Congenital malformations of the liver are not common. There are cases of absence of the liver, and of defect of one of the lobes or irregularity in the lobes. What may be called supernumerary livers have also been found in the form of isolated pieces of liver tissue in the suspensory ligament. Of more importance is congenital absence of the gall bladder, along with which there is usually a dilatation of the bile ducts.

The liver is sometimes **Transposed** along with a general transposition of the viscera. In a case recorded by Fraser, there was not only a transposition but an occasional **Dislocation** of the liver, which came down into the left inguinal region.

An **Acquired deformity** is the so-called **Stay liver** of females. This deformity is usually stated to be due to tight lacing, but although doubtless greatly aggravated by this, it is also induced by the ordinary methods of suspending the garments by a tight ligature round the waist. The effect on the liver is that it is greatly flattened, while a transverse shallow depression forms along the upper surface, affecting chiefly the right lobe. In this groove the capsule is thickened, and there is obviously considerable loss of liver tissue. Sometimes the atrophy along this groove is such that the two portions can be folded together. With the flattening there is great displacement of the liver, the lower edge of which may extend as far down as the umbilicus. More or less of this deformity is to be found in nearly all female bodies, and also in the bodies of men who have been in the habit of wearing tight belts round their waists.

Sometimes the upper surface of the right lobe of the liver presents elongated depressions passing from behind forwards, which are really **Folds of the liver**, and are produced chiefly when there is some obstruction to expiration. In that case the diaphragm is depressed by the dilated lung, and at the same time the lower ribs are drawn down in violent expiratory movements by the abdominal muscles, and pressed against the liver, which is supported below by the contraction of the abdominal muscles.

The liver is very liable to **Changes of position.** Tumours or fluid in the abdomen carry it upwards. Depressions of the diaphragm press it downwards. The suspensory ligament may be elongated so that the organ is unduly movable, and may undergo displacement downwards.

II.—AFFECTIONS OF THE CIRCULATION IN THE LIVER.

1. **Passive hyperæmia.**—This is perhaps the commonest of all affections of the liver. The names **Nutmeg liver** and **Red atrophy** are sometimes given in cases of prolonged passive hyperæmia, these names indicating certain appearances presented by the tissue. Passive hyperæmia occurs when any obstruction exists in the circulation of such a nature as to interfere with the return of blood from the inferior vena cava to the right side of the heart. The commonest cause is valvular disease of the heart, especially mitral disease, but it also results from obstruction to the pulmonary circulation as in bronchitis and emphysema, etc. In these cases there is a general engorgement of the systemic venous circulation, with increase of blood-pressure in the veins. As the normal circulation in the liver is unusually slow, and the blood-pressure low, any increase in the blood-pressure in the general venous circulation will tell particularly on the vessels of the liver, and we may even suppose that the blood passing up the inferior cava may in such cases regurgitate into the hepatic vein.

The result of this is very great distension of the hepatic vein and its radicles—the central or intralobular veins. The distension extends to the capillaries, which, as in Fig. 607, are sometimes found enormously dilated. The dilated capillaries by pressure cause **Atrophy of the hepatic cells**, and it often happens that the central parts of the lobules are entirely occupied by enormously dilated capillaries, while the hepatic cells are hardly visible (Fig. 608). The remains of the hepatic cells frequently contain brown **Pigment granules.** The atrophy of the hepatic cells in these regions may be complete, only a few pigment masses representing them. Sometimes, instead of a simply atrophy we have **Fatty degeneration** of the hepatic cells, localized in the central parts of the lobules.

Sometimes in addition to these changes there is a hypertrophy of the connective tissue surrounding the lobules, but this is usually inconsiderable, and it is a mistaken view that a cirrhosis of the liver arises out of passive hyperæmia.

To the naked eye the organ appears unduly red. On close examination even of the general surface, but more especially of the cut surface, it is seen that there are minute areas of a deep red colour corresponding with the central parts of the lobules, and these are surrounded by zones of a grey or yellowish colour. The result is that the lobules are, as it were, mapped out by these contrasting colours, and are for the most part individually visible to the naked eye. Sometimes several adjacent lobules are almost completely occupied by dilated vessels, and there is a narrow ring of normal tissue around each, so that the portion of liver has, as a whole, an almost cavernous structure and presents a deep red colour on section. It is these variations in colour and figuring which give the cut surface the appearance of the section of a **Nutmeg**.

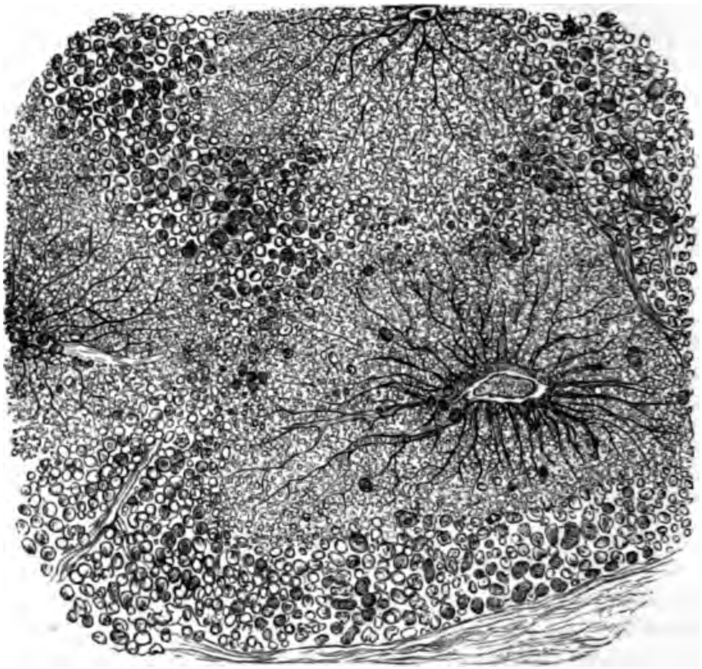

Fig. 607.—Passive hyperæmia of the liver. One lobule and parts of two others are shown. In the central parts of the lobules there is almost nothing but dilated capillaries containing blood-corpuscles; a few atrophied and pigmented hepatic cells being visible. At the peripheral parts of the lobules the hepatic cells are seen, many of them pigmented. × 50.

In parts where there has been great loss of the proper tissue, the liver may appear to the naked eye after death partially atrophied.

·ing life the dilated veins and capillaries are distended with blood, after death, the blood-pressure being removed, these may, to some ;nt, collapse. In this way the surface has sometimes a granular earance, which may be mistaken for that of cirrhosis, but it will

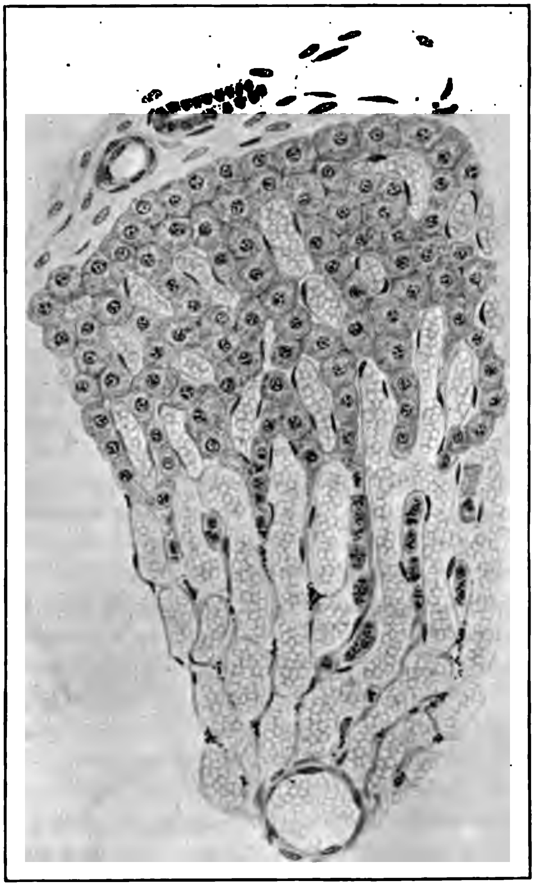

Fig. 608.—Passive hyperæmia of the liver, showing atrophy of the hepatic cells.

noticed that the depressed or atrophied parts have a deep red ur.

. **Thrombosis and Embolism.**—Thrombosis of the **Portal vein** is of ewhat frequent occurrence, especially as a result of cirrhosis. It occurs sometimes by propagation of thrombosis from the radicles he vein, or by embolism from them. The consequences to the liver :f, even of complete closure of the portal vein, are not so important ıight be expected. It is stated by some that it may lead to cirrhosis of the liver, but there is no proper foundation for this statement, and cirrhosis is much more frequently the cause than the result of thrombosis. It has also been asserted that diabetes mellitus may occur as a result of thrombosis of the portal vein. The consequences outside the liver are much more important. There is dilatation of the radicles of the portal vein in the abdominal viscera, with ascites, which is generally extreme. The results in this regard are essentially similar to those which occur in cirrhosis, and are referred to more particularly below, under that heading.

Thrombosis and embolism of the **Hepatic artery** are not usually of consequence unless the plug be of a septic nature. The hepatic artery is not an end-artery, and if some of its branches be obstructed the anastomosing communications restore the circulation. Besides this the portal vessels remain to nourish the hepatic tissue if the hepatic artery be obstructed.

Embolism of the hepatic vein by solid bodies passing backwards by gravitation from the inferior vena cava has been observed in a few cases (Recklinghausen). Thrombosis of this vein occurs in cases of cancer and of abscess of the liver.

III.—RETROGRADE CHANGES IN THE LIVER.

1. **Necrosis.**—On account of the double blood-supply of the liver necrosis seldom occurs. In a case of rupture of the liver, however, in which fissures cut off the blood-supply from a wedge-shaped piece, the author observed the appearance of the pale infarction. The tissue both in naked-eye and microscopic characters showed the appearances of coagulation-necrosis. There is also necrosis in connection with the pyæmic abscess.

2. **Atrophy.**—The hepatic parenchyma is very liable to atrophy. We have a **General atrophy** in cases of emaciation and inanition, and also as a senile phenomenon. In these cases the liver is small in size and deep in colour.

Local atrophy of the liver is usually the result of pressure, as by tumours growing in the liver, by dilated capillaries in passive hyperæmia, by the swollen capillaries in amyloid disease, or otherwise. Indeed the hepatic cells seem very readily to give way before pressure, so that, for example, one often sees in the neighbourhood of a growing cancer the hepatic cells flattened out concentrically and atrophied.

3. **Parenchymatous infiltration.**—This occurs, as we have previously seen, in connection with many acute diseases. It is this which causes the enlargement of the liver in the acute fevers, pneumonia, erysipelas, etc. The hepatic cells are highly granular (see Fig. 211, p. 384), and

if the albuminous granules be destroyed by liquor potassæ it will be seen that there are numerous fine fat-granules, showing the cloudy swelling passing into fatty degeneration.

4. **Fatty degeneration.**—This is frequently seen as a further stage of the condition just mentioned, and is a special feature in acute yellow atrophy to be presently described. It is also usually present in pernicious anæmia. A more localized fatty degeneration is met with in consequence of local affections of the liver, as in passive hyperæmia, but more especially in cirrhosis of the liver. It is characterized by the presence of minute fat-granules in the protoplasm of the cells (see Fig. 214, p. 387).

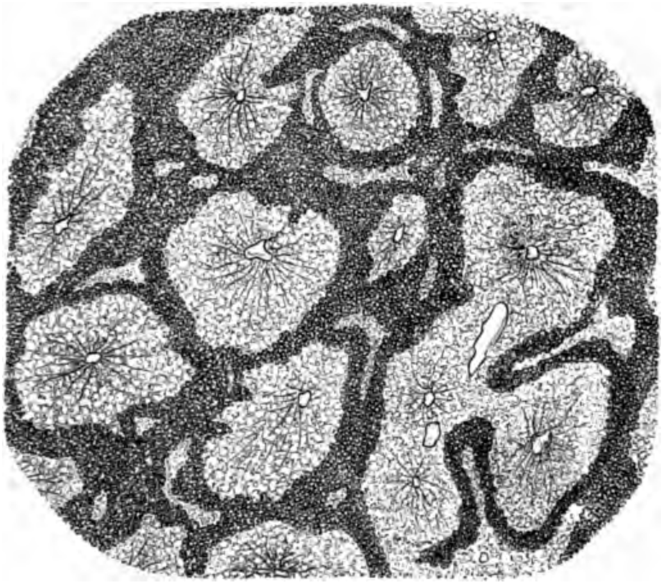

Fig. 609.—Fatty infiltration of the liver; osmic acid preparation as seen with a low power. The peripheral parts of the lobules are demarcated by the fatty infiltration. × 16.

5. **Fatty infiltration.**—The pathology of this condition has been referred to in a former part of this work (see p. 391). It is most typically seen in phthisis pulmonalis and in some other wasting diseases. It also occurs, although in a somewhat different form, in chronic alcoholism. A localized fatty infiltration in the fissure of the suspensory ligament is very common.

In fatty infiltration fat is brought by the portal vessels and deposited in the hepatic cells. It is first deposited in those nearest the terminals of the portal vein, that is to say, in the peripheral parts of the lobules (see Figs. 609 and 221, p. 392), so that at first each lobule has a peripheral zone of fatty infiltration. This is very markedly seen when a section is examined microscopically in the fresh state or stained with osmic acid. In the latter case the fatty peripheral parts become of a blackish colour, and the section assumes a very striking appearance as shown in the figure. As the condition advances, more and more of the lobule is affected, until finally infiltration overtakes its whole extent. Even in extreme cases, however, it usually preponderates at the peripheral parts. The fat is present in larger and smaller drops inside the hepatic cells, but the tendency is for the drops to assume a considerable size (as in Fig. 610). The protoplasm of the cells is pushed aside by the fat, but its function is not apparently interfered with. The stellate cells of Kupffer are sometimes specially affected.

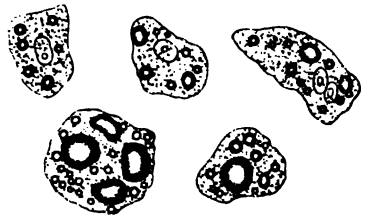

Fig. 610.—Fatty infiltration of liver. The cells are isolated, and they contain larger and smaller drops of oil. × 350.

The fatty liver is increased in weight, and in extreme cases it may be double the normal. The organ is enlarged generally, rounded at the edges and increased in thickness. It is unduly soft in consistence and has an opaque pale yellow colour which may be very marked, and merge towards a saffron yellow. It is nearly always possible with the naked eye to distinguish evidences of the lobular distribution of the fat. The lobules are, in fact, mapped out in the most characteristic figured manner, so that, on looking closely, we can distinguish each with perfect accuracy.

The appearance presents a considerable resemblance to that of the nutmeg liver, where also the lobules are mapped out; but in the fatty liver it is by unduly pale tissue at the peripheral parts of the lobules, which contrasts with the normal central parts; while in the other case it is the normal which is at the periphery, and it contrasts with the red central parts, and the whole cut surface is unduly red.

In **Chronic alcoholism** the fat is more generally distributed. The liver as a whole has a soft greasy appearance, and fat will be found in larger and smaller drops throughout the lobules.

6. **Amyloid degeneration.**—The liver is usually affected when amyloid disease exists in the body, but the affection shows great differences in degree. It may be very slight in the liver while very advanced in the spleen and kidney, and *vice versâ*. It is not known how these differences are determined. In phthisis pulmonalis, which is the most frequent cause of amyloid disease, we have all varieties in distribution.

The degeneration appears first in the arteries and capillaries, the earance in the latter being as if, at intervals, the wall were swollen by a translucent material. In these earlier stages there is no ficulty in making out that inside the lobules it is the capillaries ich are affected (Fig. 611). The general arrangement of the capillaries beautifully shown by the rose-pink colour in a section stained with thylviolet, the appearance being almost that of an injected specimen. en in the earlier periods considerable atrophy of the hepatic cells

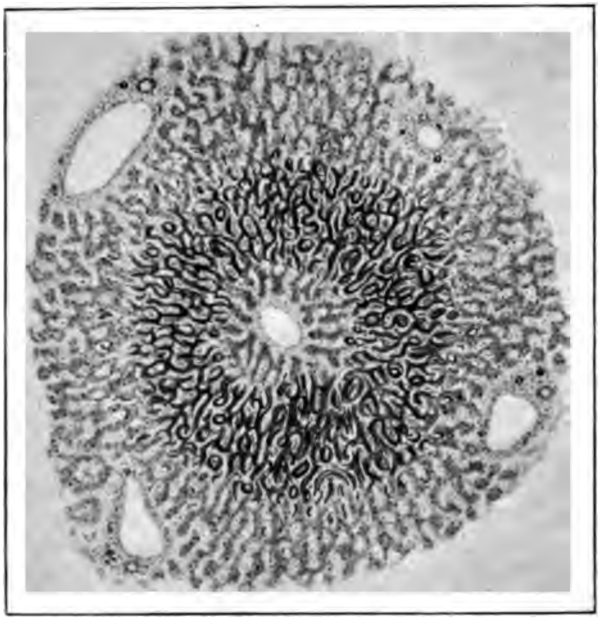

Fig. 611. Waxy degeneration of the liver. An early stage. × 50.

be observed as a result of pressure from the swollen capillaries, d the atrophic cells frequently contain fat. In advanced stages the ls are very greatly destroyed, so that the liver tissue is replaced amyloid substance. The tissue still shows indications of the lobular angement, and also of the capillaries, although scarcely any hepatic ls remain (see Fig. 225, p. 398).

It is remarkable that, with this great loss of the secreting substance, re is actual increase in the size and weight of the liver. It is not common to find the liver weighing two or three times the normal. e increase in size is not proportionate to that in weight, as the amyd substance is of greater density than the liver tissue. The edges of organ are rounded and its consistence elastic and resistant. The surface, and especially the cut surface, is homogeneous and presents a peculiar translucent waxy appearance, which in advanced stages is highly characteristic.

7. **Pigmentary infiltration.**—The hepatic tissue is liable to a considerable number of different forms of pigmentation.

Icterus is the most frequent and obvious cause of pigmentary infiltration of the liver. We have here to do with hepatogenous icterus, arising from obstruction of the bile ducts. When the bile ducts are obstructed the secretion of bile does not cease, and as excretion is hindered there occurs a re-absorption of the bile. As the hepatic cells lie between the biliary capillaries and the blood, the bile must traverse the former to reach the latter, and consequently the hepatic cells are most immediately and directly stained with the re-absorbed biliary pigment. The pigment at first stains the cells generally, but when the process is prolonged, the bile is deposited in the cells as solid granules, which have a deep brown or greenish colour. The pigmentary deposit occurs chiefly in the central parts of the lobules. The bile sometimes condenses in the biliary capillaries and forms solid plugs or moulds of these.

In the adult **the biliary colouring matter**, although similar in constitution to hæmatoidin, **rarely forms crystals.** In the newly born we have already seen (p. 396) that icterus is associated with a crystalline condition of the pigment. There is some reason to believe that in ordinary **icterus neonatorum** the pigment is hæmatoidin of hæmatogenous origin. The author is able to say, however, that in true obstructive icterus in infants, the pigment forms crystals. He found it so in a case of congenital atresia of the ducts, and in one of obstruction due to thrombo-phlebitis of the umbilical vein.

This biliary infiltration of the liver occurs in consequence of an obstruction either of the main duct (ductus communis) or of the finer ducts in the substance of the organ, as in cases of **Cirrhosis and Cancer** of the liver, having in that case a partial distribution according to the disposition of the lesion which causes it.

Infiltration with hæmosiderin (see p. 394), derived from the blood-pigment occurs, as already mentioned, in pernicious anæmia. In **Pernicious anæmia** there is a reddish brown pigment deposited in the hepatic cells, which may give a general coloration to the organ as a whole. In addition, granules **containing iron** are present in the liver, and may be detected by the dark colour which they assume on the addition of sulphide of ammonium or by the blue colour with ferrocyanide of potassium and hydrochloric acid. (See Fig. 275, p. 462.)

IV.—ACUTE YELLOW ATROPHY OF THE LIVER.

This disease, although by its name it is connected with a definite lesion in the liver, is really a general one, due to a **morbid poison** in the blood. In some cases the poison seems to be septic in its character, the disease coming on in the course of septic infection, especially in the puerperal state or in erysipelas, but generally no definite poison can be traced. Several observers have sought to connect the disease with certain forms of microbes (Klebs, Zander, etc.). In connection with its origin from a morbid poison it is interesting that phosphorus produces changes so similar that some observers have suggested that acute yellow atrophy is always due to poisoning with phosphorus. This view, however, is not tenable.

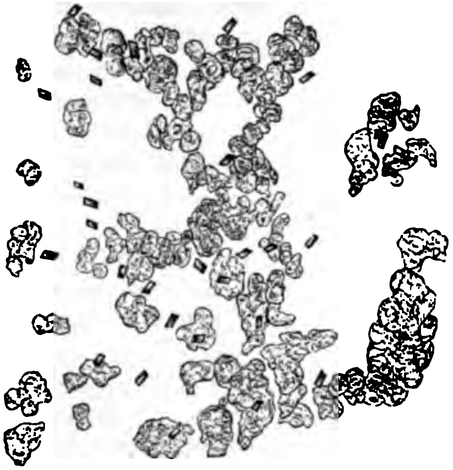

Fig. 612.—From liver in acute yellow atrophy. The hepatic cells form irregular clumps. There are numerous pigment crystals of similar shape to the crystals of hæmatoidin (Fig. 28, p. 98), and of a similar deep red colour, but smaller. × 350.

Although at post-mortem examination the liver is nearly always reduced in size, yet in some cases it is found enlarged, and there is reason to believe that in the earlier stages it is generally **enlarged**. The enlarged liver is of a brownish yellow or bright yellow colour, either generally or in streaks and patches. In these parts the cells are enlarged and full of fat granules. Although this is a true fatty degeneration, yet the fat is in comparatively large drops.

In the further stages the liver is found **smaller** than normal, and its tissue is soft and flabby. The capsule is often wrinkled from the atrophy of the substance of the organ, and the organ flattens out by its own weight, its thickness being greatly diminished. The diminution in size often affects the left lobe especially. On cutting into the organ the section shows usually different shades of colour. The predominating tint is **yellow**, varying from the colour of gamboge to a dark yellowish brown. Mixed with this, however, there is tissue of a red colour forming the **red substance** of Zenker. Where the colour is yellow the tissue is softest, but the red parts are the most atrophied, the red substance arising by the absorption of the degenerated hepatic cells.

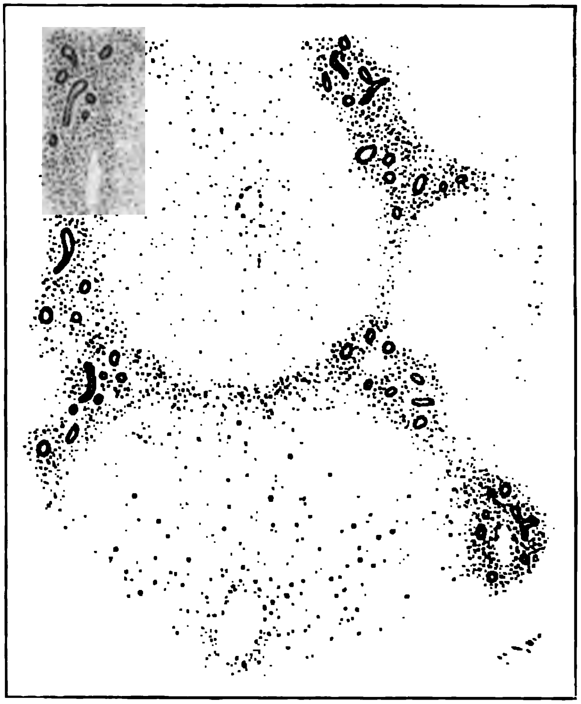

Fig. 613.—Liver in acute yellow atrophy. × 50.

On examining the yellow tissue under the microscope, it sometimes is hardly recognizable as that of the liver (see Figs. 612 and 613). There are no proper hepatic cells, but instead irregular masses containing fat drops and granular debris, with here and there rhombic crystals of a reddish brown colour. The **Crystals of pigment** have the characters of those of hæmatoidin and bilirubin. Sometimes **Leucine** is found in opaque clumps, white in colour and generally stratified. Acicular crystals of **Tyrosine** are also found.

The red substance does not present the abundant fatty debris: that has been cleared away, and there is now a fibrous material visible, nerely sprinkled with fat granules. In the red substance there are evidences of new-formation in the form of glandular-looking processes, which has been taken to indicate an attempt at regeneration of the ost hepatic substance, beginning in the capillary network of the hepatic ducts.

Besides the changes in the liver, there are lesions of a somewhat similar character elsewhere, especially in the epithelium of the kidneys and the muscular fibre of the heart. The symptoms are those of a general disease.

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V.—HYPERTROPHY AND REGENERATION OF THE LIVER.

Experiments in animals have shown that removal of portions of the liver is followed by a regenerative growth of the various structures of the organ, this growth being by the usual process of Karyomitosis. The growth is not limited to the neighbourhood of the lesion, but the whole liver may take part in it. It has been stated by Ponfick that after removal of from a half to three fourths of the volume of the liver, there occurs in a comparatively short time such a compensatory hypertrophy of the rest of the tissue as to restore the original weight of the organ.

In man there are evidences of a similar power of **compensatory hypertrophy** and regeneration when portions of the liver are lost by disease or injury. In a case observed by the author there had been a ongenital loss of a large part of the right lobe, apparently from some njury early in fœtal life, as the right kidney was also wanting. In his case the left lobe was greatly increased in size, and the liver as a whole was of normal dimensions. A similar though probably more imited compensatory hypertrophy occurs from destruction of the liver issue in adult life. The destruction may result from syphilitic disease, from pressure of hydatids, from cicatrices, and even from cirrhosis. The region of the atrophy will determine that of the hypertrophy; sometimes the left lobe or the lobus Spigelii undergoes great enlargement.

There are some cases in which the liver as a whole is enlarged without any apparent alteration in structure, as if from a general hypertrophy. This is commonly the case in rickets. The liver is usually but not always enlarged in diabetes.

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VI.—INFLAMMATIONS OF THE LIVER.

1. **Suppurative hepatitis.**—Acute suppurative inflammation occurs in connection with septic processes, which have been propagated to the liver.

(*a*) **The Tropical abscess** is scarcely ever met with in this country, except in persons who have been in hot climates, especially in India. Much doubt exists as to the cause of the inflammation which gives rise to the abscess. In a large proportion of cases it is associated with dysentery, and it is believed by many that the abscess in the liver arises by the amœba coli or by septic microbes being carried from the ulcerated intestine to the liver. This view, however, is not beyond question, and post-mortem examination shows that tropical abscess is by no means uniformly associated with dysentery. It is possible, indeed, that an existing abscess by causing congestion of the portal circulation may predispose to inflammation of the intestine (Finlayson). It is not unlikely that certain states of the liver predispose to the development of the agents in question, and that they may find entrance to the body without any lesion of the intestine.

A confirmation of this view is furnished by the fact, testified by Dr. David Wilkie of Simla, that in India, while the death-rate from dysentery among natives is not far from that among Europeans, that from hepatitis is proportionally greater amongst Europeans, probably from predisposition, brought about by their mode of living and racial characteristics. Thus in the European and native armies from 1877 to 1886 the death-rate from dysentery per 1000 men was 1·33 and 1·25 respectively (or, including diarrhœa, 1·57 and 2·27), whereas the death-rate from hepatitis was 1·45 in the European and 0·17 in the native army. This is more strikingly apparent in the deaths in the jails of India (natives), the death-rate being, dysentery and diarrhœa, 1877-1886, 19·13; hepatitis, 0·22.

The abscess is mostly, but not always solitary, and before death it generally grows to large dimensions, causing great enlargement of the liver. Having approached the surface, it sometimes causes a marked projection from the liver. The abscess may rupture into the peritoneum and cause fatal peritonitis, or its capsule having become adherent to the abdominal wall it may subsequently find its way to the surface of the body, and there discharge. It also occasionally bursts in other directions, as through the diaphragm into the pleural cavity or lung;

into the colon or other part of the intestine; or into the gall-bladder, from which the pus is carried to the duodenum. In these various ways the pus may be disposed of and perhaps recovery occur, but more frequently a wasting discharge from the cavity of the abscess remains.

In other cases the abscess does not enlarge, but rather dries-in. A thick connective tissue capsule forms around it like the wall of a cyst, and the pus thickens to a cheesy consistence. Afterwards the contents may become calcareous and the disease may become virtually obsolete.

(*b*) **Pyæmic abscesses** are produced by pyogenic micrococci conveyed to the liver by the blood. They may be carried by the hepatic artery, in which case they have generally been absorbed from a septic wound and have traversed the lungs. Such abscesses will usually be associated with similar metastatic abscesses in the lungs. On the other hand, the microbes may be conveyed by the portal vein, being associated with a septic thrombo-phlebitis in its radicles, or in the vein itself. The author has twice seen abscesses in the liver from the ulceration of gall-stones into the portal vein and consequent thrombo-phlebitis.

Where the source of infection is in the systemic venous system the abscesses may form without any visible thrombosis or embolism of the portal or hepatic vessels. It appears that, if the microbes are in the blood reaching the liver, they may settle there just as other granular matter may do.

The microbes multiply and form zooglœa in the capillaries and interlobular veins, passing into the central veins. Wherever the colonies extend the liver tissue undergoes necrosis, the cells lose their nuclei and become individually indistinguishable. Inflammation is produced around, and there is here, as elsewhere under similar circumstances, an acute suppurative inflammation. The round cells accumulate around the necrosed portion, and gradually infiltrate it and break it down, so that an abscess forms.

The abscesses in this form are always multiple, and some of them may attain large dimensions. In accordance with what has been stated the actual abscess is preceded by a grey or yellowish discoloration indicating the existence of necrosis of the tissue. There will be probably a group of such areas corresponding to necrosed hepatic lobules. Ultimately these break down and form a common abscess.

(*c*) **Biliary abscesses** occasionally form in connection with obstruction of the ductus choledochus. This will result when decomposition occurs in the stagnant bile and extends into the ducts in the substance of the liver. (See further on under Obstruction of Bile Ducts.)

2. **Chronic interstitial hepatitis. Cirrhosis.**—We have to do here with a chronic inflammation of the interstitial connective tissue of the organ.

Causation.—As the disease occurs for the most part homogeneously throughout the organ, the irritant is contained in the blood circulating in the liver. The name "gin-drinker's liver," frequently applied to this disease, involves the view that alcohol is commonly the irritant. Alcohol taken frequently in the form of undiluted spirits is believed to cause the disease, while beer and wine do not. But the disease may originate from other kinds of irritation whose nature is obscure. It has been produced experimentally by chronic poisoning with phosphorus and cantharides, and it probably occurs also as a result of syphilis. It has been met with in young children, and the author has recorded a case in which a typical cirrhosis, with the usual secondary phenomena, occurred in a cat. The fact that it was a butcher's cat may indicate that it indulged in excess of eating rather than of drinking. Greenfield has also recorded two cases of cirrhosis in the cat.

Obstruction of the bile ducts has been asserted as a cause of cirrhosis, and a special form of **Biliary cirrhosis** has been distinguished. There are undoubtedly cases which have this origin, but, on the other hand, there are many cases of biliary obstruction with no such result. In any case biliary cirrhosis forms a small proportion of the cases of cirrhosis, and on the whole the disease is hæmatogenous in its origin.

Character of the lesions.—In cirrhosis we have chronic inflammation of the connective tissue of the liver, resulting in new-formation of a similar tissue. The interstitial connective tissue of the liver follows, as we have seen, the portal vessels, forming a framework in which are supported the portal vein and its branches, the hepatic artery and hepatic duct. The new-formation occurs in the great majority of cases only in these regions, that is to say, outside the lobules. In the earlier stages the affected connective tissue is abundantly cellular, like granulation tissue, and the process of new-formation is evidently similar in its details to that in other chronic inflammations (see Fig. 614).

As a general rule the new-formed tissue undergoes development into dense connective tissue which has a tendency to shrink. By its shrinking it causes **Atrophy of the proper hepatic tissue.** As the cirrhosis is usually multilobular the contracting tissue isolates groups of lobules of larger or smaller size, and these, consisting of soft tissue, stand out somewhat when the liver is divided, or present themselves prominently at the surface. There are thus areas of remaining hepatic tissue which are being gradually encroached on by the connective tissue. The atrophy of the hepatic tissue takes place by the supply of blood being cut off. By the contraction of the new-formed tissue the portal vessels, and especially the interlobular branches, are narrowed. The hepatic artery is not much affected by the contracting tissue. Indeed, as the hepatic artery supplies the active connective tissue there is a new-formation of capillary blood-vessels in connection with its terminal branches. Injected preparations show that the hepatic artery is pervious, and that the new-formed connective tissue is highly vascular.

The destruction of the hepatic cells takes place to a large extent by fatty degeneration, and one can often see, in the midst of connective tissue, islands representing hepatic tissue consisting of little more than collections of oil-drops. The hepatic tissue is also commonly stained with bile pigment of a yellow or brown colour, and this we may associate with obstruction of the bile ducts by the contracting connective tissue. For the most part the pigment is biliary, but it is also to some extent blood pigment arising from the obstruction to the circulation. The connective tissue is also commonly stained, and to the naked eye the cut surface has a yellow colour, sometimes with here and there quite an orange tint. The name of the disease, cirrhosis, was originally applied from the colour of the altered organ.

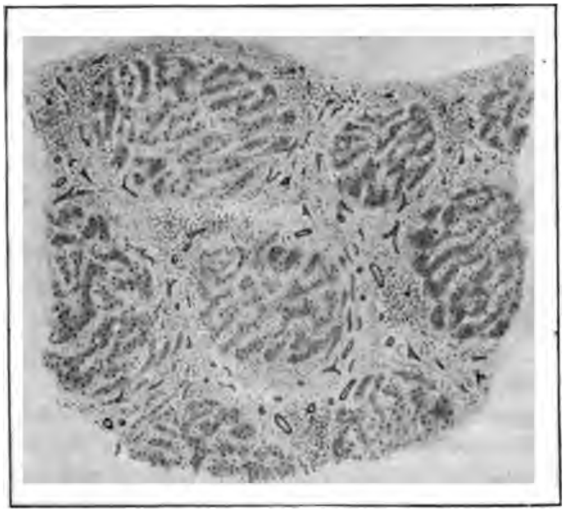

Fig. 614.—Cirrhosis of the liver. × 40.

A prominent feature in microscopic examination in many cases is the presence of narrow elongated canals, lined with epithelium, which are usually described as **Capillary bile ducts**. They are present in the midst of the connective tissue, sometimes very abundantly, and, as no such ducts exist there normally, they are in a certain sense new-formed. By some authors (especially Charcot and Gombault) they are regarded as entirely new-formed, and their existence is taken as characteristic of a special form of cirrhosis. They are, however, to be found in all forms of cirrhosis, and are probably to be regarded as the biliary capillaries, which have survived the destruction of the hepatic tissue. The larger bile ducts, which run in the capsule of Glisson, are unaltered, apparently not being affected by the shrinking connective tissue.

In its macroscopic appearances the liver varies considerably. In the earlier stages it is enlarged, but as a result of the changes detailed above it undergoes atrophy and distortion. The connective tissue contracts, and as it is irregularly distributed the contraction is irregular. The surface of the organ presents larger or smaller projections consisting of the less affected hepatic tissue between the cicatricial depressions. These projections may be comparatively large, forming the **Hob-nail appearance** of the surface, or they may be smaller, giving a **generally granular appearance**. They are usually yellow or brown and opaque, being fatty and stained with pigment. Sometimes there is special shrinking of the left lobe, and generally there is dragging in of the edges, so that the liver assumes more of a **compacted form**, being perhaps even thicker than usual, but reduced in superficies. It is dense to the feeling, and more tough to cut than normal. On the cut surface it may be possible with the naked eye to make out the grey connective tissue, with islands of opaque or pigmented hepatic tissue in it.

The terms **Biliary cirrhosis** and **Hypertrophic cirrhosis** are in frequent use, especially in French medical literature. The former of these was used by Charcot to indicate the mode of origin of the affection, the expression indicating that the irritation extended from the bile-ducts. This form was distinguished in its causation from the hæmatogenous or venous, in which the irritation extended from the blood-vessels. The biliary form arises in connection with obstruction and inflammation of the bile ducts. In this form there are, according to Charcot and Gombault, two distinctive features, namely (1) that the new-formation of connective tissue exists somewhat uniformly, so that the individual lobules are surrounded by it—the so-called **Monolobular cirrhosis**; and (2) that the capillary ducts already referred to are visible. To this last condition great importance has been attached.

It is to be acknowledged as a result of experiment that obstruction of the bile ducts leads to an increase of connective tissue in the liver, and to a monolobular cirrhosis. In man such a result sometimes follows on biliary obstruction. It did so in a case observed by the author of congenital stenosis of the bile ducts. There was great biliary infiltration and an extreme monolobular cirrhosis. At the same time, as cirrhosis is by no means a constant result of biliary obstruction, there must be an element yet to be elucidated.

Hypertrophic cirrhosis is a name given by another French author, Hanot, and it applies to the same class of cases. The biliary monolobular cirrhosis is characterized by hypertrophy of the liver.

The ordinary alcoholic cirrhosis in its early stage may show considerable hypertrophy, the new-formation may be monolobular in its distribution, and there may be the most marked new-formation of capillary ducts.

The author is able to refer to a case which he examined post mortem. It was carefully watched for six weeks during life by Sir William Gairdner. When first observed there was great enlargement of the liver, and there was reason to believe that it had been greater. The patient had been addicted to alcohol for over two years. There were hæmorrhages from stomach and bowels, and marked ascites, but little or no jaundice. After death the liver was found small, weighing 43 oz., and finely granular on the surface. There was a great excess of connective tissue, which presented many round and spindle-shaped cells, and was monolobular in its distribution. The hepatic cells contained abundant fat in small and large drops. In this case the cirrhosis, although monolobular and at one period hypertrophic, was not connected with obstruction of the bile ducts.

Outside the liver the principal changes depend on **Obstruction of the portal circulation.** The connective tissue narrows the portal vessels in the liver, and this leads to a chronic passive hyperæmia in all the radicles of this vein, in the peritoneum, in the mucous membrane of the stomach and intestine, in the spleen, and so on. The most frequent consequence is ascites, but we also meet with hæmorrhages from the mucous membranes, especially of the stomach and large intestine, as well as catarrh. The spleen also is enlarged. Occasionally thrombosis of the hepatic vein results, and this may extend to the vena cava. A very large hæmorrhagic infarction of the lung was observed by the author as a result of embolism from a softened thrombus of this kind.

The obstruction of the portal vein often leads to widening of the venous channels which form communications between the portal radicles and the **Systemic veins.** In this way we may have great dilatation of the internal hæmorrhoidal veins (leading to piles) and of the hypogastric veins. The cutaneous branches of the latter often stand out prominently on the abdominal wall. The hæmorrhoidal veins also communicate with the vesical, and these latter may undergo dilatation. There may also be widening of the communications between the veins of the diaphragm and œsophagus, which have sometimes been found highly varicose. Another channel occasionally met with is a small vein which runs from the portal vein to the umbilicus. In some cases this is so much enlarged as to approach the size of the portal vein itself.

The patient generally dies from the disorders due to the continuous passive hyperæmia—the persistent catarrh of the alimentary canal, perhaps with hæmorrhages, the ascites, etc. There is great emaciation and sometimes icterus. It is not clear that the mere loss of the function of the liver bears an important part in the fatal result.

3. **Perihepatitis.**—This condition is an inflammation of the capsule of the liver, and it is always secondary to some other lesion. A chronic pleurisy of the right side often extends through the diaphragm, and causes inflammation of the subjacent peritoneum, including the under surface of the diaphragm and upper surface of the liver, so that firm adhesion is the result. This is often the case in phthisis pulmonalis. A general chronic or acute peritonitis usually involves the capsule of the liver as well as other parts of the peritoneum. Sometimes cirrhosis or syphilitic disease of the liver extends to the capsule.

The inflammation is in most cases chronic, and results in a thickening of the capsule. Sometimes there are shaggy papilliform projections from the capsule, and there is frequently adhesion to the parts around, especially to the diaphragm. The thickened capsule undergoes contraction like the new-formed connective tissue in other inflammations, and the result frequently is considerable deformity of the liver. The capsule, contracting all round the liver, doubles-in its anterior edge, causing the organ to assume an approach to the globular shape. The contraction causes also atrophy of the liver tissue, and seriously interferes with the circulation in the organ.

Literature.—*Suppurative inflammations*—Frerichs, loc. cit.; Murchison, loc. cit.; Buckling, 36 Fälle v. Leberabscess., 1868; Klebs, Handb., ii.; Budd, Dis. of liver, 2nd ed., 1852; Dickinson, Path. Trans., xxxii., 1881; Fayrer, Tropical dysentery and diarrhœa, liver abscess, etc., 1881; Finlayson (with literature), Glas. Med. Jour., v., 1873. *Cirrhosis*—Budd, Frerichs, etc., loc. cit.; Liebermeister, Beiträge z. path. Anat. u. Klinik der Leberkrankheiten; Charcot, Leçons sur les malad. du foie, 1877; Hanot, Cirrhose hypertrophique avec ictère., 1876; Saundby, Path. Trans. xxx., 1879; Legg (Expers. by ligature of bile duct), St. Barth. Hosp. Rep., ix., 1873; Osler, Med. Times and Gazette, 1881; Dreschfeld, Jour. of Anat. and Phys., xv.; Brieger, Virch. Arch., lxxv., 1879; Krönig (Cirrhosis from phosphorus-poisoning), Virch. Arch., cx., 1887; Rolleston and Hayne, Brit. Med. Jour. i., 1901.

VII.—SYPHILIS AND TUBERCULOSIS OF THE LIVER.

1. **Syphilis.**—The changes in the liver in syphilis are very marked and somewhat frequent. It manifests itself for the most part as an indurative interstitial inflammation, with or without the formation of gummata. There may be a **Cirrhosis** indistinguishable from the ordinary forms of this disease, and only judged to be syphilitic from other circumstances. Sometimes in the midst of the general new-formation of connective tissue there are numerous **Small gummata** about the size of peas, distinguished especially by their caseous condition.

For the most part, however, the disease is localized. To the naked eye the liver is seen to present one or several **Cicatrices** which often make deep indentations in its surface. These cicatrices are most frequent in the neighbourhood of the suspensory ligament. On cutting into the middle of the cicatrix a **Gumma** with its central part caseous is usually divided. The periphery of the gumma is not distinctly demarcated from the surrounding connective tissue which extends outwards into the hepatic tissue. Other gummata may be found more deeply in the liver tissue, and these also are surrounded by cicatricial tissue.

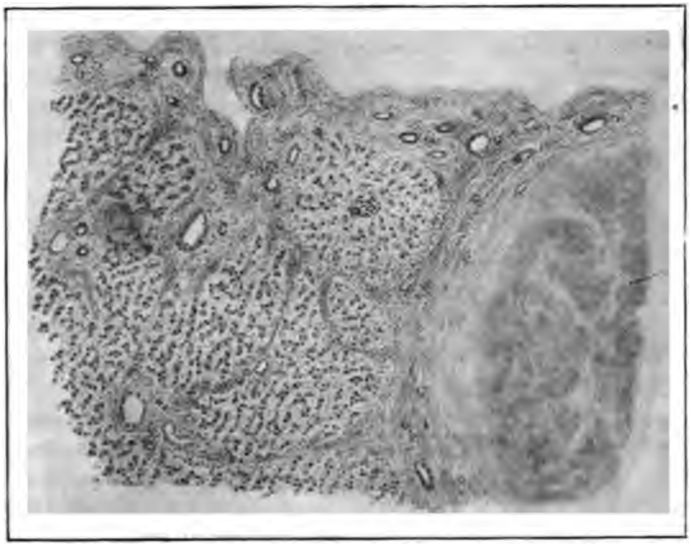

Fig. 615.- Gumma of the liver. × 40.

The cicatrix is composed of fibrous tissue, and the gumma itself frequently presents irregular strands of connective tissue, but giving place to round-cell tissue. The caseous portion contains merely granular debris (see Fig. 615). Sometimes at the periphery of the gumma there is great dilatation of blood-vessels, giving almost a cavernous appearance.

When there are a considerable number of gummata, the cirrhosis may be nearly continuous, but with special cicatricial contractions at intervals corresponding to the gummata. The liver in this way may assume a very striking appearance, as if subdivided into manifold small lobes. Be the cicatrices large or small in number, the lobed and subdivided condition is characteristic of the syphilitic liver.

The liver is sometimes found affected in infants who are the subjects of **Congenital syphilis** (see page 184). It may be a general induration forming a cirrhosis, usually with enlargement and perhaps numerous small gummata; or the induration may be more localized, but never with that cicatricial condition which we find in acquired syphilis. The connective tissue formation in this case does not confine itself to the neighbourhood of the portal vessels, but extends into the lobules, so that between the cells and around the capillaries there is connective tissue, forming the so-called **Monocellular cirrhosis** of Charcot.

2. **Tuberculosis.**—Secondary tuberculosis of the liver is very frequent, while primary tuberculosis is exceedingly rare.

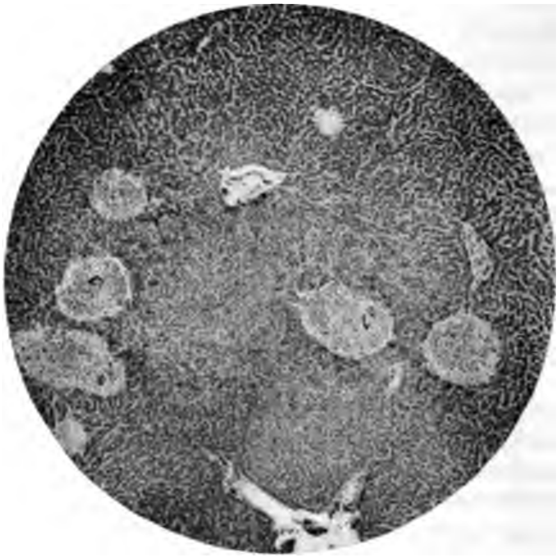

Fig. 616. - Tubercles in the liver in acute general tuberculosis. × 35.

Primary tuberculosis, in the few cases which have been recorded, was in the form of solitary tubercles like those in the brain. In one recorded case the mass reached the size of the fist.

Secondary tuberculosis.—In ordinary local tuberculosis of various organs a few bacilli get into the blood and reach the liver at intervals, where the conditions of the circulation allow of their settlement. The resulting tubercles are so small as to be scarcely visible to the naked eye. The tubercles are not very numerous but sufficiently so as to be readily detected in microscopic sections. In this class of cases the tubercles are in various stages, most of them old and degenerated their central parts. Small tubercles are thus frequent in the r, yet they rarely attain to more than microscopic dimensions, and condition can scarcely be called a tuberculosis.

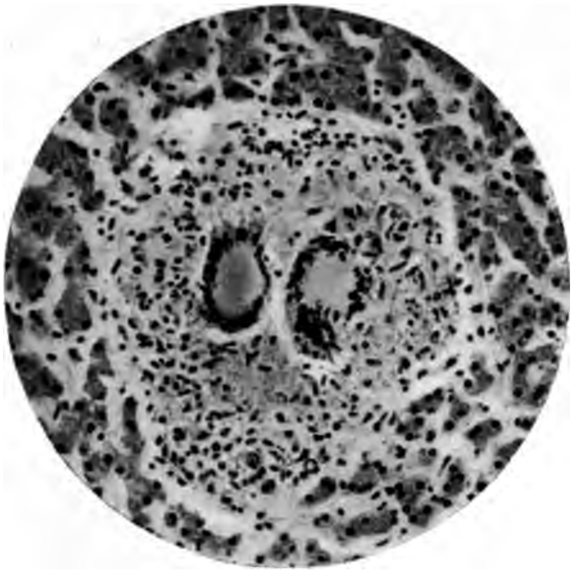

Fig. 617.—Tubercle in the liver in acute general tuberculosis. × 200.

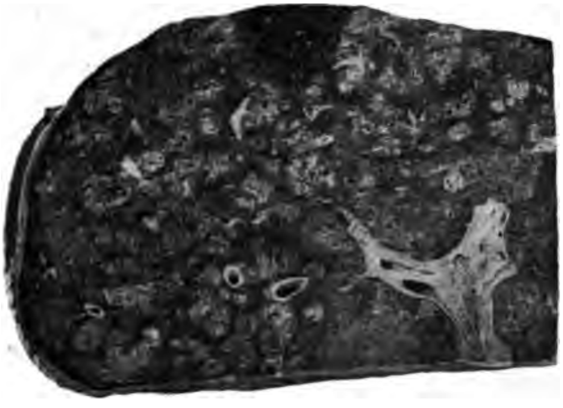

Fig. 618.—Tuberculosis of the liver extending by the bile ducts.

n acute miliary tuberculosis the bacilli are abundant in the blood . the tubercles in the liver are very numerous, although still so small to be with difficulty seen with the naked eye (Figs. 616 and 617). tubercles here are usually found in an earlier stage and they present the typical structure, the giant-cells being often very prominent.

A rare form is **Tuberculosis of the bile ducts.** It occurs in the form of large caseous nodules with cavities in the centres which are filled with softened matter coloured with bile. The wall of the cavities shows tubercles. It is possible that in this form the extension may be by the lymphatics from the porta of the liver (see Fig. 618).

Besides syphilis and tuberculosis we have **Glanders** manifesting itself in the liver, especially in horses. The nodules are moderate in size and tend to calcify. In **Actinomycosis** the liver is often secondarily involved (see Fig. 88, p. 217). **Leprosy** produces nodules in the connective tissue. There are also new-formations occasionally in **typhoid fever** and **diphtheria.**

VIII.—TUMOURS AND PARASITES OF THE LIVER.

Cavernous angioma of the liver is the commonest form of primary tumour. Its structure has already been described (see p. 308 and Fig. 138). It develops apparently by dilatation of the existing capillaries and atrophy of the intervening hepatic cells, so that the tumour replaces a certain portion of hepatic tissue. When seated immediately under the capsule the tumours are visible as red blotches, and on section they have a red colour and collapsed appearance. Usually it is only after the blood is washed out that the white trabeculæ become visible. The tumours present great varieties of size and may be as large as the fist. They occasionally project outwards from the general surface of the liver, but are generally level with this surface. In a case recently recorded by Mantle an unusually large tumour, measuring 12 by 8 inches, projected downwards from the right lobe and occupied the right iliac fossa.

A case has been described by Ziegler of multiple **Fibroneuroma** in the liver on the fibres of the sympathetic, there being similar tumours on the various nerves of the body except the olfactory and optic.

Cysts are not infrequent in the liver, and they may be multiple. It is curious that multiple cysts of the kidneys and liver frequently co-exist, both forms being probably of congenital origin. The cysts in some cases replace a considerable portion of the liver tissue. A group of bulky thin-walled cysts occupies a large part of the liver substance. There is rarely an extreme transformation of the whole liver or a great part of it, such as occurs in cystic transformation of the kidneys.

In **Leukæmia** the liver is very frequently the seat of new-formations. This may take the form of a general infiltration of the interstitial connective tissue, but it often occurs as individual small nodules, somewhat embling miliary tubercles but without the presence of giant-cells or tendency to caseation. The round cells which form the nodules e been observed to show evidences of karyomitosis. The capillaries commonly filled with leucocytes and the liver as a whole is much arged. Similar conditions are observed sometimes in Hodgkin's ease.

Concerning **Adenoma** of the liver there is considerable variety in ement and opinion, mainly because, on the one hand, this form of our is rare, and, on the other, there are tumours concerning ich it is difficult to say whether they should be called cancers or nomas. The form designated **Nodular hyperplasia** is clearly an noma, and the name may with convenience be confined to this form, the other so-called adenomas have more the habit of cancers. It urs as well-defined solitary or multiple tumours which have a similar ucture to the proper hepatic tissue, except that the cells are usually ger and some have double nuclei (see Fig. 155, p. 319). If single tumour may reach the size of a cherry or larger; if multiple the nours are usually smaller. The larger ones are sometimes surrounded a connective tissue capsule. These tumours are of no practical sequence and are met with accidentally. They are not uncommon the liver of the dog.

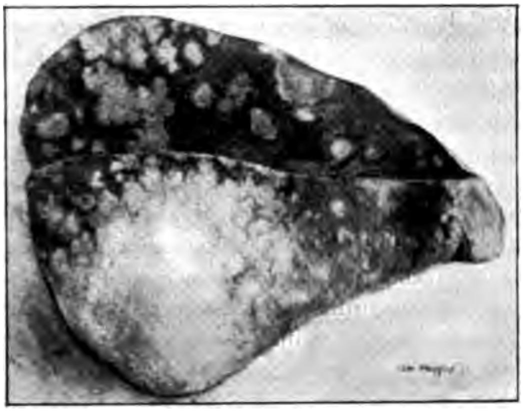

Fig. 619.—Primary cancer of the liver with secondary nodules. The bulky tumour in the anterior part of the right lobe is the primary cancer. (From a painting by Dr. A. MACPHAIL.)

Adenoma of the liver is not infrequently associated with **Cirrhosis**, t the nature of the connection is not apparent.

Primary cancer.—This form of tumour is infrequent compared with ondary cancer, but in itself is not very uncommon. It occurs sometimes as a massive tumour involving a large part of the liver, but in addition to this large tumour there are frequently numerous secondary ones in the liver substance (see Fig. 619). In some cases the growth seems to arise from the bile ducts at the porta of the liver, and to extend into the substance of the organ. In regard to structure several forms have been distinguished, of which the principal are these:

Cylinder-celled epithelioma is a rare form of tumour in the liver: it is sometimes described under the name of tubular adenoma. In its structure it closely resembles the similar tumours of the stomach and rectum, consisting of tubular gland-like processes with cylindrical epithelium. As is usual with this class of tumours the cells in many of the alveoli are variously shaped and the typical structure is only visible at the growing margins. There may be several tumours or one large one. The structure of the tumour suggests an origin from the hepatic ducts, but according to Rindfleisch the gland processes arise from the hepatic cells inside the lobules. This form of tumour is not usually malignant, but in a case recorded by Greenfield secondary extension to a lymphatic gland and to the lungs had occurred.

Primary cancer in the liver has more frequently the structure of **Ordinary cancer**, which sometimes has the dense characters of **Scirrhus**. It may involve a considerable portion of the liver, perhaps the whole left lobe, and by shrinking reduce it to small dimensions. In structure the tumour presents the ordinary characters. At the marginal parts it may be seen sending processes into the hepatic capillaries and into the branches of the portal and hepatic veins.

There are also cases of so-called **Infiltrated** or **Diffuse cancer** in which the whole liver is affected. The organ is enlarged and granular on the surface, resembling the appearances in cirrhosis. There is here also a great increase of connective tissue, but in its meshes there is cancerous and not liver tissue. This form is sometimes called **Cirrhosis carcinomatosa**. It is as if there had been a great transformation or replacement of the liver tissue by cancer.

Lastly there is the form in which the cancer originates in the **larger ducts** and extends along the capsule of Glisson. The radiating appearance of the new-formation is visible in this form, and there is also obstruction of the ducts with retention of the bile and icterus.

Secondary cancer.--This is of very frequent occurrence in the liver. There may be a **direct extension** of a cancer from the gall-bladder or the stomach. In the latter case the organ becomes adherent and the cancer grows into the liver. There may thus be a large tumour, sometimes with a cavity communicating with an ulcerated surface in the stomach.

Metastatic cancer is more frequent. The primary tumour is usually in the stomach or intestine, but it may be in the œsophagus, uterus, mamma, or elsewhere. In most cases the cancer extends to the liver by the portal vessels (see further on as to Extension of Cancers in the Abdomen), but it may also occur by the hepatic artery in cases of cancer of the mamma and other external parts.

As the cancer is sown in every part of the liver, the consequence is the development of numerous tumours which may be found in all stages of growth (see Fig. 620). It is usual to find a large number of isolated tumours of circular form and pale colour (see Fig. 621). They are seated in the liver tissue, but those near the surface produce rounded elevations which can often be felt through the abdominal parietes during life. Even to the naked eye the tumours show evidences of fatty degeneration in the appearance of an opaque yellow coloration. The absorption of the degenerated cells is also indicated by the partial contraction of the larger tumours in their central parts. In the superficial ones a dimpling or **Umbilication** of the rounded projections is commonly visible. The liver, as a whole, is sometimes

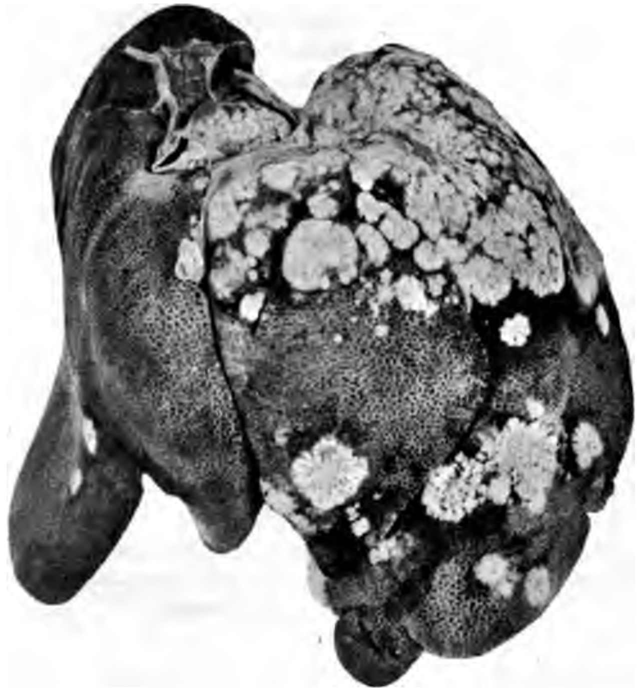

Fig. 620.—Secondary cancer of the liver of a cat. The primary growth was in the mammary region.

enormously enlarged, weighing not infrequently as much as ten or twelve pounds.

An exceedingly rare form of secondary cancer is that represented in

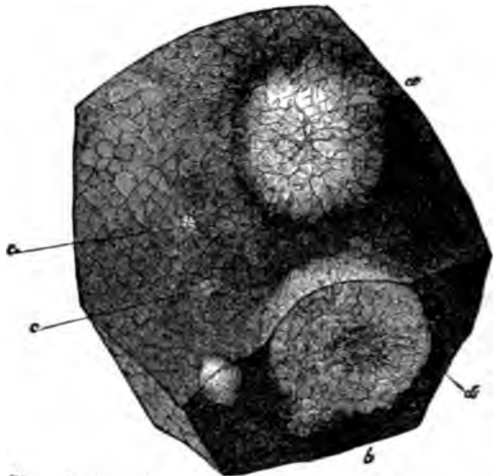

Fig. 621. Piece of a liver showing secondary cancerous tumours. A large one, *a*, is viewed from the surface. Another large one, *b*, in section. There are several smaller tumours, *c*, *c*; *d*, a vein in section. (VIRCHOW.)

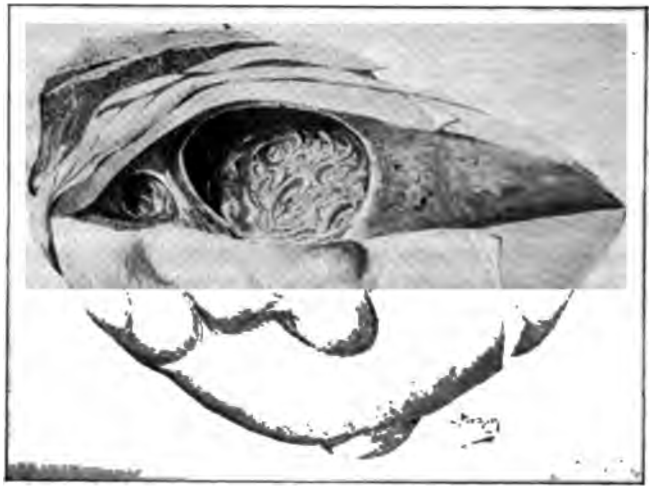

Fig. 622. Cystic cancer of liver. (From a painting by Dr. A. McPHAIL.)

Fig. 622, in which there was a congeries of cysts as well as solid tumours, the walls of the cysts and the tissue of the solid tumours presenting cancerous tissue. The cysts arose by necrosis of the tissue and contained blood and debris.

In some cases the new-formation is not so much in the form of individual tumours as a general **Cancerous infiltration**, as if almost throughout the liver a simultaneous development had occurred, and the cancerous tissue had grown vigorously, displacing the proper hepatic tissue.

In structure the secondary tumours follow the primary ones. For the most part it is soft cancers of the stomach that form the original tumours, and we have a well-formed stroma with irregular masses of epithelial cells. But sometimes the primary tumour is an epithelioma, and in that case the tumours in the liver are usually fewer in number, firmer and more distinctly defined. When the primary tumour is in the œsophagus the structure may be that of the **Flat-celled epithelioma** with the usual laminated capsules. When the primary tumour is in such a position that the cancer reaches the liver by the hepatic artery, the tumours are usually smaller in size and the liver not so much enlarged. This was at least very strikingly seen in a case observed by the author, where the primary tumour was in the mamma.

The cancerous material as it is brought by the blood frequently develops **inside the vessels**, and particularly in the portal veins and the capillaries. The growing tumours cause atrophy of the proper hepatic tissue. The hepatic cells are often to be seen at the peripheral parts of the tumours arranged in concentric layers as pressure is exercised, and in various stages of atrophy.

The numerous developing tumours press on the bile ducts and obstruct them, and this occurs all the more as the growths mostly arise by embolism of the portal vessels, and are, in the first place, related to them. As the ducts are in the immediate neighbourhood of these vessels, they are liable to be pressed on very soon. Hence **General icterus** is a common result, and there is also a special **Pigmentation** of the hepatic tissue (*vide ante*).

The portal vessels suffer obstruction, not only by the pressure of the tumours, but as being the seat of their primary growth, and hence **Ascites** is a common result.

Sarcoma is of occasional occurrence in the liver in the spindle-celled and pigmented forms. Some cases of melanoid sarcoma have been described as primary tumours, but secondary tumours following melanotic sarcomas of the eye are more common. The liver may be largely occupied by these black tumours, and greatly enlarged. Here also the growth appears to occur in the blood-vessels and results in the destruction of the hepatic tissue proper.

Deciduoma malignum in its late stages may show metastases in the liver (Fig. 623).

Parasites of the liver.—These have already been somewhat fully described. The most important arises from the **Tænia echinococcus**, and constitutes the **Hydatid** of the liver. When the liver is examined after death there is found a sac or sacs of very various size, up to that of a man's head. The larger ones produce necessarily great enlargement of the liver as a whole, and atrophy of the hepatic tissue around them. They present first a connective tissue capsule, inside which the proper wall of the cyst appears. As the vesicles are sometimes much broken down, and it may even be difficult to find hooklets, it is important to remember that the proper cuticula of the cyst is lamellated. In the contents of such cysts there are frequently orange-coloured masses consisting of crystals having the usual form of the hæmatoidin or bilirubin crystals. They are probably composed of bilirubin. The multilocular and exogenous forms of hydatids have been already mentioned, the former it may be remembered resembles colloid cancer in its general appearance.

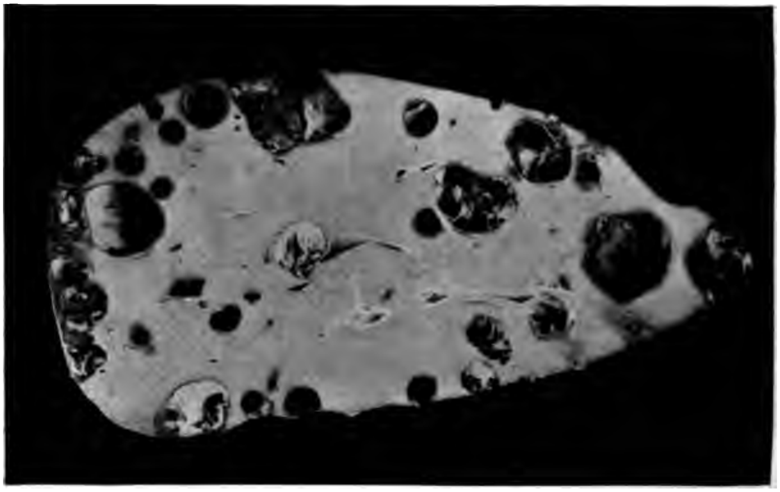

Fig. 623.—Metastasis of deciduoma malignum in the liver. The organ was extremely pale and fatty.

It is not uncommon to meet with the remains of a dead echinococcus in the liver. It shows a capsule which contains an indefinite debris in which pieces of the chitinous membrane are visible (Fig. 624). There may be several such lesions present. In a case of this kind the author found in one of the cysts along with calcareous infiltration a production of true bone in the wall of a small collapsed cyst. In Fig. 262, p. 433, a microscopic section of a shrunken hydatid is reproduced.

The **Distoma hepaticum, sinense,** and **lanceolatum** occur in the bile ducts, the **Distoma hæmatobium** in the portal vessels. (See under Animal Parasites.) The **Pentastoma denticulatum** also occurs in the liver.

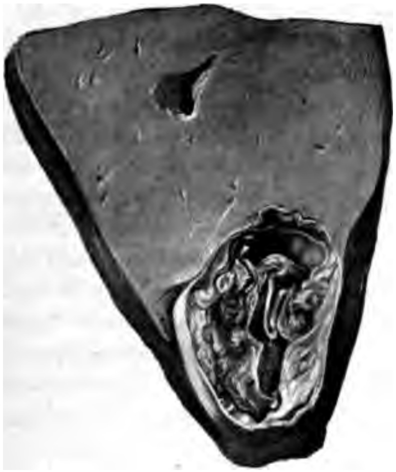

Fig. 624.—Portion of liver with collapsed hydatid cyst. Natural size.

Literature.—*Nodular hyperplasia*—Friedreich, Virch. Arch., xxxiii., 1865; Hoffmann, ibid., xxxix., 1867; Sabourin, Rev. de méd., 1884; Simmonds, Deutsch. Arch. f. klin. Med., xxxiv., 1886; Greenish, Wien. med. Jahresb., 1882. *Cavernous Angioma*—Mantle, Brit. Med. Jour., 14th Feb., 1903. *Primary cancer*—Rindfleisch, Path. Hist. (Syd. Soc.), 1872-73; Greenfield, Path. Trans., xxv., 1874; Mahomed, ibid., xxviii., 1877; Whipham, ibid., xxii., 1871; Paul, ibid., xxxvi., 1885; Waldeyer, Virch. Arch., lv., 1872; Perls (Cirrhosis carcinomatosa), ibid., lvi., 1882; Dreschfeld, ibid., and Jour. of anat. and phys., xiv., 1880; Weigert, Virch. Arch., lxvii., 1876; Hilton Fagge, Path. Trans., xxviii., 1877; Pye Smith, ibid., xxxi., 1880; Hanot et Gilbert, Étude sur les malad. du foie, 1888. *Cysts*—Sabourin, Arch. de physiol. norm. et path., x.; 1882, and Progrès méd., 1884, No. 20; Recklinghausen, Virch. Arch., lxxxiv., 1881; Kennedy, Edin. Lab. Reports, iii., 177, 1891.

B.—The Bile-Ducts and Gall-Bladder.

1. **Gall-stones.**—These are of very frequent occurrence, especially in people past middle life, and they are often found in the gall-bladder after death without their existence having been suspected during life.

The cause of their formation is very obscure. They are formed in the gall-bladder by the deposition of the constituents of the bile, chiefly cholestearine and next to that bile pigments, but also lime and magnesia salts in varying proportions. Probably stagnation of the bile in the gall-bladder at least predisposes to their formation, and this is rendered the more probable from their more frequent occurrence in old people where the actions are sluggish. In the centre of gall-stones there is frequently a nucleus composed of remains of epithelium or mucus, and it has been supposed that catarrh of the bladder may furnish this nucleus.

Gall-stones occur singly or in numbers. The **Single gall-stones** are commonly composed almost purely of cholestearine, of which there may be over 98 per cent. They are oval in shape, somewhat nodulated on the surface, and have a glistening appearance, altogether somewhat resembling in appearance a sugar plum. When divided or broken they present a characteristic radiation from the centre, and also sometimes a concentric stratification. The stone is very light in weight, floats in water when previously dried, and has a soft almost soapy feeling.

Multiple gall-stones are more frequent, and although sometimes consisting of nearly pure cholestearine, they are more frequently composed of this mixed with bile pigment and lime salts. There may be two or three, but they may be present in large numbers, fifty, a hundred, or several hundreds or thousands (as many as 7800 have been counted). If few they may be comparatively large, but if numerous they are small, the bladder sometimes having the appearance of a bag filled with peas. The multiple stones are always facetted, taking their shape according as there is room, and fitting into each other. In appearance they have been compared to the macerated carpal bones, having somewhat similar facets, and often presenting a similar greyish colour, although sometimes yellow, brown, or even black. They are very light in weight, and on section present little of the glistening appearance or radiating arrangement of the single ones. On the contrary they are more commonly stratified, owing to more deeply and less deeply pigmented strata alternating.

Gall-stones composed almost entirely of **bile-pigment** are very rare. They are small, nodulated, and nearly black, and occur in considerable numbers at a time. Stones composed mainly of **Lime salts**, especially the carbonate, are still rarer.

The condition of the **Gall bladder**, which is the seat of gall-stones, varies somewhat. It is often completely collapsed on the calculi, so that it is a tightly filled bag of stones. In other cases there is a small amount of bile in the bladder, whilst in others a tough mucus surrounds the calculi.

Gall-stones frequently **leave the bladder** and pass into the cystic duct, where they may remain for a time and cause obstruction. Later they often pass on into the ductus choledochus. The last part of this duct is narrow, and, if the stone is of any considerable size, it usually sticks here, at least for a time. By dilating the duct it may get into the duodenum, but very commonly it finds its way through by ulceration, and sometimes it ulcerates into the peritoneum, producing peritonitis. Lying at the mouth of the ductus communis it obstructs the outflow of bile and produces the results to be presently described. When it gets into the duodenum it usually passes off with the fæces, but if large, it may produce **Obstruction of the intestine** at some point. This is of rare occurrence, and can scarcely happen except in the case of large stones, chiefly of the solitary kind.

The calculus may ulcerate from the gall-bladder directly outwards. It may thus pass into the peritoneum, or into a neighbouring canal such as the portal vein. These are, however, rare occurrences.

2. **Obstruction of the bile-ducts.**—Obstruction occurs from various causes, of which one of the commonest is **Gall-stones** as described above. **Inflammation** of the ducts sometimes produces obstruction, the inflammation being nearly always due to an extension of catarrh from the stomach and duodenum. As the duct near the orifice is narrow a trivial inflammatory swelling may produce an obstruction, which the bile, possessing a low pressure, is unable to overcome. **Tumours** and **inflammations around** the duct may cause obstruction. This is not infrequently the case with **Cancers of the head of the pancreas** or those involving the lymphatic glands in the portal region of the liver. We have already seen that an obstruction of the hepatic ducts in the substance of the liver occurs in cancer of the liver, in cirrhosis, etc.

Congenital atresia of the main bile ducts is by no means an uncommon lesion. The ducts in part or as a whole are reduced to the condition of solid threads, or they are altogether indistinguishable. This is due to a defect occurring mostly in early fœtal life, and in some instances several members of the same family have been affected. The occlusion leads to intense icterus, and in this case as in icterus of newly-born children generally the bilirubin assumes the crystalline form. An intense monolobular cirrhosis often results. **Inflammation and thrombosis of the umbilical vein** producing swelling around the duct at the porta of the liver was a cause of obstruction in a newly-born child observed by the author. A septic thrombo-phlebitis resulted after the separation of the cord. In this case also the bilirubin had a crystalline form.

The **Results of obstruction** vary according to the site of the obstruction. The usual result is **Icterus** or **Jaundice**, but this does not occur if the obstruction be limited to the cystic duct, as is not uncommon in the case of gall-stones.

If the **Cystic duct** alone be obstructed then the consequence is that no bile can get into the gall-bladder. In that case the bladder **may shrink**, and any mucus in it may dry-in and perhaps afterwards become chalky. In many cases, however, there is an abundant secretion of mucus, and the bladder becomes filled with it. The mucus often after a time gives way to a more fluid secretion, and the bladder may be converted into a thin-walled cyst (**Hydrops vesicæ felleæ**) which may be as large as the fist, with clear fluid contents.

When the gall-bladder is thus cut off and no longer available as a store for the bile, there sometimes occurs a **Dilatation of the larger bile ducts** chiefly in the portal region of the liver, so that the bile may lie here instead of in the gall-bladder, and pass into the duodenum during digestion. This constitutes an imperfect compensation for the loss of the gall-bladder. **Gall-stones** may form in the dilated ducts.

In the case of **Obstruction of the ductus choledochus**, there is stagnation both in the gall-bladder and in the whole system of bile ducts. The stagnation tells first on the gall-bladder, which dilates readily and stores up the bile. There may even be rupture of the gall-bladder from excessive dilatation. If the obstruction be prolonged great dilatation occurs throughout the whole system, and serious changes frequently result in the liver itself.

Next to the gall-bladder the ductus choledochus and the larger bile ducts, which are not supported by the firm liver tissue, are most liable to dilate. This dilatation may be very extreme, these ducts becoming sometimes as great in circumference as the thumb, and it may even go on to rupture.

Sometimes considerable atrophy of the proper tissue of the liver occurs, and we have the smaller bile ducts dilated and forming numerous cavities or **Cysts** throughout the liver.

There is sometimes even an **Acute inflammation** of the bile ducts apparently from decomposition of the bile, and this may lead to **Biliary abscesses.** This occurs when the obstruction is incomplete, as when it is produced by the pressure of the tumour, and there is therefore the possibility of the propagation of septic decomposition from the duodenum to the stagnant bile. There may be numerous abscesses filled with a tenacious bile-stained pus.

3. **Rupture and Perforation.**—Rupture of the gall-bladder or of the ducts outside the liver may occur from over-distension, or it may be the result of injury. The rupture takes place into the peritoneum and the bile causes **peritonitis**. The inflammation is sub-acute, causing great thickening of the peritoneum. A peculiar appearance is some-

times produced, the thickened peritoneum presenting an orange-coloured surface from biliary staining.

4. **Tumours of the bile-ducts and gall-bladder.**—Of these the most important are **Cancers.** We sometimes meet with primary cancer in the gall-bladder resembling in structure cancer of the stomach and intestine. By extension it may largely involve the liver tissue. In the great majority of cases gall-stones are present in the gall-bladder in cases of primary cancer, and the irritation of the calculi is to be regarded as the cause of the cancer (see Fig. 625). We have already seen that some of the cancers of the liver probably take origin in the finer bile ducts in its substance.

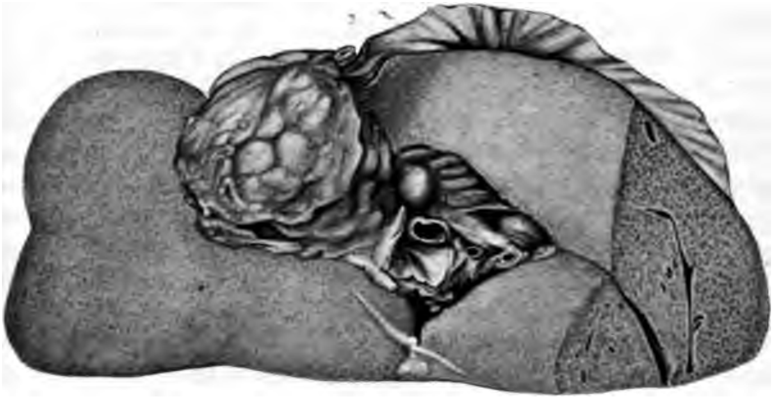

Fig. 625.—Cancer of the gall-bladder. The lumen was almost entirely filled by the growth. In the cystic duct a number of gall-stones were found.

Occasionally small nodules consisting mainly of glandular tissue and muscle are met with projecting from the mucous membrane of the gall-bladder.

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C.—THE PANCREAS.

The pancreas has the structure of a salivary gland, consisting of glandular acini whose ducts communicate with a main duct lying in the centre of the gland (Wirsung's duct) and opening into the duodenum in common with the ductus choledochus.

The function of the pancreas seems to be similar to that of the salivary glands, but the gland possesses two pathological relations, which have not yet obtained a full explanation but are of great importance. These are the relations of the organ to the absorption of fat in the alimentary canal, and to the occurrence of diabetes. Extirpation of the pancreas seems to hinder the absorption of fat, and disease of the organ which causes destruction of the tissue or obstruction of the duct seems to have a similar effect, so that fat appears abundantly in the fæces. The relation of the pancreas to diabetes has been already referred to at pp. 227 and 228.

Malformations occur chiefly in the form of supernumerary or accessory glands (Fig. 626). These are usually situated in the wall of the stomach, duodenum, or jejunum. Another malformation is that in which the pancreas surrounds the duodenum.

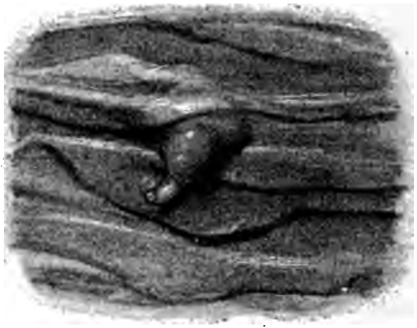

Fig. 626.—Accessory pancreas in the small intestine.

The pancreas is occasionally the seat of **Hæmorrhages** into its substance (*Pancreatic apoplexy*). These may be the result of injuries to the abdominal wall or the consequence of passive hyperæmia in diseases of the heart, lungs, or liver. Some cases of sudden death have been recorded by Zenker, Hooper, and Klebs, in which the most obvious lesion was hæmorrhage into the substance of this gland. No cause for the hæmorrhage was apparent. It is supposed that the lesion caused pressure on the neighbouring cœliac plexus and semilunar ganglion and a consequent reflex paralysis of the heart, just as inhibition of the heart is producible by blows on the abdomen (Goltz's experiment). The hæmorrhage may be associated with necrosis or with inflammation (*Hæmorrhagic pancreatitis*) leading sometimes to abscess formation (Fig. 627). The abscess may burst into the peritoneum.

Inflammations of the pancreas are of various kinds. Besides the abscess just mentioned we have suppurative pancreatitis like suppurative parotitis, resulting in abscesses; also indurative interstitial inflammation with loss of gland tissue, this condition being sometimes of syphilitic origin.

Atrophy of the pancreas is observed often as a part of general emaciation, but it has been found in a good many cases of **Diabetes mellitus.**

Fatty infiltration of the pancreas is one of the commonest lesions of this gland. There is normally some adipose tissue in the midst of the gland, and this sometimes undergoes considerable increase, the proper glandular substance becoming atrophied, and adipose tissue taking its place, the shape and general appearance of the gland being preserved. The condition may be part of a general obesity, or it may occur in old age, and, in this latter case, it may be presumed that atrophy of the glandular tissue is the first condition, the adipose tissue developing afterwards, as in fatty infiltration of voluntary muscle. **Necrosis** sometimes occurs in the adipose tissue of the organ, producing opaque yellow patches of a striking character.

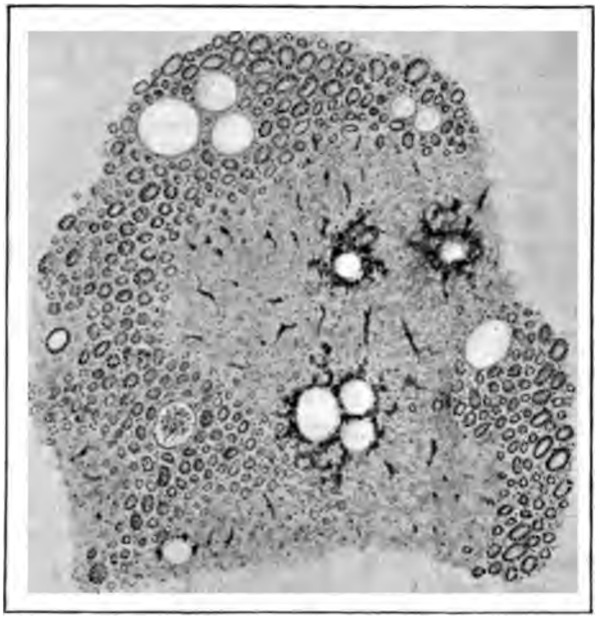

Fig. 627.—Hæmorrhagic pancreatitis. Areas of necrosis and hæmorrhage are shown. × 50.

The glandular structure sometimes undergoes **Cloudy swelling,** in common with that of the liver and other organs in the acute fevers. **Fatty degeneration** is also met with.

Tuberculosis is not common in the pancreas, but we meet with caseous masses having the characters of a local tuberculosis. More frequently the pancreas is involved secondarily in a tuberculosis arising in neighbouring lymphatic glands. Syphilitic **Gummata** have been observed.

Of the tumours of the pancreas, **Cancer** is by far the most important. It occurs most frequently in the head, rarely in the body or tail. It is mostly a dense tumour of fibrous appearance (scirrhus), but cases of soft and of colloid cancer have been seen. The cancer often obstructs Wirsung's duct, or produces still more serious results by obstructing the ductus communis. It may even by its retraction or by its prominence cause a partial obstruction of the duodenum. There may arise in this way considerable disturbances from the continuous extension of the tumour. We may also have secondary tumours in the lymphatic glands, liver, or peritoneum.

Cancers of the stomach or duodenum rarely extend to the pancreas. The gland is sometimes the seat of secondary metastatic tumours when the disease becomes generalized.

The **Pancreatic duct** (Wirsung's) is liable to certain changes. **Concretions** occur in it, comparable to those of the salivary glands. They are mostly round or oval and white or greyish white. In size they have been met with as large as a hazel nut or larger, but they are usually small like grains of sand. They are composed chiefly of carbonate and phosphate of lime. They very often arise in dilated ducts, but if large may cause dilatation by obstructing the duct.

Obstruction and Dilatation of Wirsung's canal may arise, as we have seen, from calculi, cancers of the head of the pancreas, or from tumours in the neighbourhood. Dilatation also occurs secondarily to atrophy of the gland. The dilated duct forms a series of pouches, or else there is a more definitely localized dilatation so that actual **cysts** are formed. The latter will occur when the orifice is completely obstructed; the cysts may reach the size of the fist or that of a child's head, and these are sometimes designated **Ranula pancreatica.** The contents of the dilated duct may be simply the fluid secretion, but sometimes there is thickening of the contents and even hæmorrhage. In this way we may have coagula causing the cysts to look like aneurysms, all the more as the lining of the cyst may become the seat of calcareous plates like the internal coat of an artery in aneurysm.

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Jour. of anat. and phys., xix., 1885; Klob, Zeitschr. d. Wien. Aerzte., 1859; Zenker, Virch. Arch., xxi. *Hæmorrhage*—Prince Morton, Boston Med. and Surg. Jour., 1882; Zenker, Berl. klin. Wochensch., 1874; Challand, Bull. de la Soc. méd. de la Suisse rom., 1877; Klebs, loc. cit.; Korte, Krankheiten u. Verletzungen des Pank., 1898; Klippel and Lepas, Arch. gén. de Méd., ii., 1899. *Atrophy and Diabetes*—Klebs, loc. cit.; Frerichs, Ueber den Diabetes, 1884; Duffey, Dubl. Jour. of Med. Sc., 1884; Israel, Virch. Arch., lxxxiii., 1881. *Concretions*—Johnston, Amer. Jour. of Med. Sc., 1884. *Cysts*—Recklinghausen, Virch. Arch., xxx.; Hjelt, Schmidt's Jahrb., clvii., 1873; Tilger, Virch. Arch., cxxxvii., 1894. *Pancreatitis*—Fitz, Trans. N.Y. Path. Soc., 1889; Opie, Jour. Exper. Med., v., 1901.

D.—THE PERITONEUM.

Introduction.—The peritoneum, which is stretched over many organs and possesses many recesses and pouches, has a superficies said to be equal to the surface of the body. It is a large lymphatic sac and fluid is constantly circulating through it. Experiments (especially those of Wegner) have shown that the peritoneum possesses great powers both of the transudation and absorption of fluid. Thus the injection of concentrated solution of sugar or of glycerine causes an exudation of serous fluid amounting in three-quarters of an hour to from 3 to 8 per cent. of the weight of the body. Again, watery fluids and even urine, bile, oil, etc., are absorbed with great rapidity without injury to the membrane, and such medicaments as morphia and chloral are absorbed much more rapidly than when injected subcutaneously. Finely divided solid matter is also readily absorbed and carried into the lymphatics. The absorption is effected presumably by stomata, by which the sac communicates with the lymphatic vessels. Whilst all parts of the peritoneum doubtless possess the power of absorption, there are two localities in which this presents points of special interest.

From certain facts to be afterwards referred to in connection with tuberculosis and cancer of the peritoneum, it may be inferred that the **Great omentum** is specially concerned in the process of absorption. This double layer of peritoneum, lying free in the cavity, may be regarded as **a drain** by means of which the fluid is drawn off.

Again, the lymphatics of the **Diaphragm** communicate on the one hand with the peritoneal sac, and on the other with the pleural cavity, so that fluid and finely-divided solids may be carried through from one to the other. It is probable that the general course of the current is from peritoneum to pleura, although it may be reversed.

This great power of absorption is very important, especially in relation to septic processes. The products of septic decomposition are readily absorbed; sometimes in such quantity as to produce fatal results before they have had time to induce any considerable local effects. This is especially the case in rupture of the intestine, where death may occur within twenty-four hours without definite symptoms of peritonitis, and apparently from absorption of the septic poison. After death, however, signs of inflammation are usually visible in the peritoneum.

The fluid in the peritoneal sac is not at rest, but circulates, and the movements of the intestines doubtless have to do with its transportation from place to place. Hence any pathogenic agent introduced into the peritoneal cavity is generally carried to every part of the sac and produces its effects in every region. Abundant examples of this are afforded by such conditions as tuberculosis of the peritoneum, inflammations, and cancer.

1. **Malformations.**—The mesenteries are sometimes too long or too short. The former condition is supposed to have to do with the causation of hernias. The latter causes the intestine to be unduly controlled in its movements. In a case recorded by Lawson Tait the peritoneum passed from loop to loop without any proper mesentery. There are also dermoid cysts of congenital origin found in the peritoneum.

2. **Disorders of the circulation in the peritoneum.**—(*a*) **Active hyperæmia** is produced when from any cause a general relaxation of the arteries in the sac occurs. Leaving inflammation out of account, this will hardly occur except as a result of sudden removal of extra pressure from these vessels. If a large ovarian tumour be removed from the abdomen, or ascitic fluid be drawn off, the arteries and capillaries which have previously accommodated themselves to the undue pressure on their walls, relax, and hyperæmia occurs. The hyperæmia may result in the occurrence of a peculiar form of **Chronic hæmorrhagic peritonitis**, comparable with hæmorrhagic pachymeningitis (see p. 791), the effused blood being here also sometimes a prominent feature (**Hæmatoma of the peritoneum**). As in the other case it may be a question whether there is an inflammation preliminary to the hæmorrhage, or whether the hyperæmia induces bleeding, the succeeding organization of the clot leading to the formation of a membranous layer on its surface. Where ascitic fluid has been drawn off many times, there may be several layers of soft membrane on the surface of the peritoneum, the innermost being the most delicate and the newest.

(*b*) **Passive hyperæmia** occurs as a result of obstruction to the portal circulation, either alone or as part of a general venous hyperæmia. It is chiefly important in relation to ascites, of which it is the most frequent cause.

(*c*) **Hæmorrhage.**—There may be unimportant hæmorrhages in the substance of the peritoneum in scurvy, hæmophilia, etc. More considerable hæmorrhages occur in consequence of rupture of larger vessels. Aneurysms of the abdominal aorta not infrequently rupture. The blood accumulates at first behind the peritoneum, but it may also pass into the cavity. Traumatic rupture of liver, spleen, or kidneys may also cause hæmorrhage although these lesions, especially in the case of the kidney, are liable to produce subperitoneal hæmorrhage. Then there are frequent hæmorrhages from the female generative organs, as from the rupture of the cyst in extra-uterine pregnancy, but it may also occur without apparent cause at menstrual periods. (See Periuterine Hæmatocele.) There are also hæmorrhages in tuberculosis and cancer of the peritoneum.

The effused blood is in many cases readily absorbed, but when the collection of blood is local, as in the pelvis, or the peritoneum is altered by inflammation, it may remain. If there is a considerable mass the name **Hæmatoma** is applied. The blood becomes decolorized and surrounded or encapsuled by new-formed connective tissue in the ordinary way. The blood thus sets up a chronic inflammation which, in the case of the pelvic hæmatoceles, may have serious consequences by interfering with the uterus and ovaries.

(*d*) **Ascites.**—This name is given to dropsy of the peritoneal cavity. It is sometimes, although rarely, a part of a general œdema, occurring in disease of the heart or lungs, in Bright's disease, and in anæmic states. It is peculiarly prone to occur when the portal circulation is specially obstructed. This may happen by the portal vein being obstructed by thrombosis, or pressed on from without, but more frequently it is by some lesion in the liver itself, such as cirrhosis or cancer, which obstructs the portal vessels, as it were, in detail.

In these cases the ascites is from increased transudation, and it is much less common to have it occurring from interference with absorption. This may have something to do with it, however, in cases of cancer of the peritoneum, where the numerous cancerous tumours originate from material carried into the lymphatic channels and growing there. These tumours will necessarily obstruct the lymphatics to a large extent in detail, whilst they may also produce by their irritation a hyperæmia of the peritoneal vessels and so lead to increased transudation.

The fluid in ascites is contained in the general sac of the peritoneum, but where adhesions have previously existed it may be confined to particular parts, and may be sacculated. Sometimes also, in children, there is a dropsy in the sac of the omentum (*Hydrops omenti*).

The character of the fluid in ascites is that of ordinary transudations, a clear, slightly yellow, limpid fluid of low specific gravity. After it has stood for a time it often deposits a very gelatinous coagulum of fibrine.

In prolonged ascites the peritoneum is apt to get somewhat thickened, especially when puncture has been frequently performed. The great omentum is not infrequently gathered up so as to be thicker and shorter than usual, and in that case it will act less efficiently as a drain.

Chylous ascites has already been referred to as occurring in connection with obstruction of the thoracic duct (see under Œdema). The fluid in the abdomen is milky, containing finely dissolved fat. Of a different nature is **Ascites adiposus**, which may be confused with chylous ascites, as in it also the fluid is milky. In this case the milkiness is from fatty degeneration of cells, either the endothelium in ordinary ascites or the cells in cancer. There is always the distinction between the two conditions that in chylous ascites the fat is free, while in ascites adiposus it is in cells.

3. **Inflammations of the peritoneum. Peritonitis.**—Inflammation of the peritoneum is very seldom spontaneous in its origin. It seems remarkable that, compared with the pleura or pericardium, this membrane is so seldom the seat of independent inflammation as a result, for instance, of the irritation of the blood in acute rheumatism, or of the more vague causes of irritation designated as cold.

The peritoneum is, however, peculiarly liable to inflammations of a secondary character, the irritant proceeding either from without as in wounds of the abdomen, or from one of the organs lying beneath the membrane.

Mere exposure to the air or the entrance of air into the abdominal cavity does not induce peritonitis, and even a somewhat prolonged cooling of the membrane, as during an operation, does not seem to lead to inflammation.

Septic inflammations.—These comprise the great proportion of acute inflammations of the peritoneum. Experiments (Grawitz, Waterhouse) seem to show that whilst the peritoneal cavity is a favourable place for the propagation of pyogenic microbes in respect to temperature and other conditions, yet its absorbent power is such that the introduction of these agents is not followed by inflammation when the peritoneum is strictly normal. On the other hand, if there be in the sac stagnant serous fluid, or irritating substances calculated to produce transudation, or if there is a septic wound communicating with the peritoneum so that the microbes are vigorously produced and nourished, then they multiply in the peritoneal cavity and evolve their specific toxins.

It is obvious that in actual cases in man the pyogenic microbes will rarely be introduced as pure cultures into a normal peritoneum as in the case of experiments. Septic inoculation takes place from a wound in the abdomen becoming septic, or more frequently by rupture of the stomach, intestine, or vermiform appendix, or by propagation of septic processes from the uterus in delivery. In the one class of cases the conditions are those of a septic wound communicating with the peritoneal cavity. In the other irritating matters from the alimentary canal are also introduced along with pyogenic agents.

If the pyogenic agents once settle in the peritoneal sac they propagate with enormous rapidity in the warm and moist cavity, and it may happen that in a comparatively few hours we may have such an absorption of toxins as to cause death by septic poisoning even before much evidence of inflammation has manifested itself.

The septic inflammations are pre-eminently acute, and tend rapidly towards suppuration. At first there is hyperæmia and a serous and **Fibrinous exudation.** The exuded fibrine is visible on free surfaces as a soft yellow layer, and is often present in the fluid as yellow flakes. It glues together surfaces which are in contact, such as the loops of the intestine, but the adhesions are soft and readily separated. As the inflammation goes on, the fibrinous exudation, which from the first contains very numerous leucocytes and is correspondingly soft, becomes still more infiltrated with these, and assumes the characters of pus. **Pus** may be found in some parts, while in others there is still the soft fibrinous exudation. Thus pus may be found in the neighbourhood of the original source of the inflammation, as around the vermiform appendix, the inflammation being here more intense or of longer standing. The pus, and even any free fibrine that may exist, commonly gravitate to dependent parts, and we may find a collection of yellow pus in the pelvis, especially in Douglas's pouch.

The endothelial cells of the peritoneum take part in the inflammation. They multiply and enlarge (Orth), or they are shed. The underlying connective tissue is infiltrated with serous fluid and exudation, and all the underlying tissues are altered, more especially the wall of the intestine, whose coats are often œdematous and swollen. There is not infrequently considerable tympanitic distension of the intestine from paralysis of its muscular coat. This **Meteorism** is sometimes a peculiarly distressing feature in puerperal fever.

Septic peritonitis, if general, is almost necessarily fatal. Sometimes it is localized by adhesions, and even after the occurrence of suppuration, may subside and give place to chronic inflammation.

A more **localized acute peritonitis** not infrequently occurs. It may be in connection with appendicitis (*vide ante*), or with diseases of the uterus, or may be even a result of infarction of the spleen. If recovery occurs from such inflammations adhesion of the surfaces affected is the result.

Chronic peritonitis, whether developing out of the acute form or occurring in connection with disease in an underlying organ, is characterized by new-formation of connective tissue, frequently with adhesion of opposing surfaces (*Peritonitis adhæsiva*). The details of this process are similar to those in chronic pleurisy; it only remains here to specify some of the more common instances of the affection.

A diffuse chronic peritonitis sometimes develops in the course of Bright's disease. There is also commonly, in cases of secondary cancer of the peritoneum, a general chronic peritonitis.

Local thickenings of the capsule of the liver and spleen are of frequent occurrence in connection with diseases in these organs or their neighbourhood. Sometimes the connective tissue is hard, almost like cartilage. Very commonly there is adhesion to the parts around, especially to the diaphragm. On the other hand, the diaphragm may be adherent by reason of the extension of an inflammation from the pleura, the irritant having passed downwards in a direction contrary to that of the usual circulation.

The peritoneum around the female generative organs is liable to very frequent local chronic inflammations (*Perimetritis*), resulting in complex adhesions and mattings of the pelvic organs. The contraction of the new-formed connective tissue may cause considerable distortion of these organs.

There is also a peritonitis from rupture of the gall-bladder or a bile duct (see p. 1046).

4. **Tuberculosis of the peritoneum. Tubercular peritonitis.**—This disease is due to the existence of the tubercular virus in the peritoneal cavity. The virus seldom gains entrance into the sac from tubercular ulcers of the intestine, apparently because the intestinal lymphatics are subperitoneal and do not communicate with the interior of the sac. Tuberculosis of the lymphatic glands, more especially those of the mesentery, seems to be the principal primary source of tuberculosis of the peritoneum. An old caseous gland may break down and rupture into the sac, and this may occur although the glands may be only to a slight degree affected. Tuberculosis of the vertebræ may give rise to it, and in some cases tuberculosis of the testicle and vas deferens has extended to the peritoneum, the disease being in that case concentrated in the inguinal region where the vas deferens approaches nearest to the peritoneum.

Having reached the peritoneum the virus is carried hither and thither throughout the sac by the regular currents. The consequence is the formation of innumerable tubercular nodules and an **Inflammation** of the peritoneum. The inflammation is at first acute, accompanied by serous and, usually, fibrinous exudation as in septic inflammations. There is thus often considerable swelling of the abdomen. In some cases the inflammation is unusually acute and it may even be suppurative in character.

By the time the case comes to be examined post mortem the acute stage has usually passed off and we find evidences of chronic inflammation in the form of thickening of the peritoneum and multiple vascularized adhesions in every part. The loops of the intestines are adherent to each other, and the superficial ones to the anterior wall of the abdomen; the omentum is adherent to the intestine; the liver to the diaphragm, and so on. In fact the peritoneal cavity is obliterated by adhesions. In the midst of these adhesions are numerous yellow masses of very various sizes, some as large as split-peas, and usually flat. These caseous masses are composed of groups of tubercles which have very much the character of those found in tubercular pericarditis. The caseous tubercles have developed in the usual way out of grey miliary tubercles, and examination will usually show examples in the various intermediate stages.

The condition of the **Omentum** is worthy of special mention. It is drawn together and thickened, and closely adherent to the intestine and wall of the abdomen, while in its substance numerous tubercular masses are to be found.

It has already been mentioned that **Tubercular pleurisy** often develops in association with tubercular peritonitis. There is in the pleura for the most part a serous and sometimes a fibrinous exudation, and as the eruption is usually recent the tubercles are in the form of small white or grey nodules. They are commonly grouped mainly in the lower part of the pleural cavity, in this way indicating the source of the infection.

Healing is not infrequent in tubercular peritonitis, but the resulting conditions are rarely the subject of observation. The author had the opportunity of examining a case ten years after the patient had passed through an attack which was diagnosed as tubercular peritonitis. The peritoneum was obliterated by soft connective tissue adhesions, which united the intestines and the various organs together. There were no tubercles visible, but here and there a small cretaceous mass in the midst of the adhesions. When the tuberculosis had been overcome the dead caseous matter had remained. This was in great part absorbed as dead animal matter. Where, from the size of the mass or otherwise, absorption did not occur, calcareous infiltration took place. The adhesion of the peritoneum may be more localized, and by the stretching of the adhesions, bands or bridles may be formed under which the intestine may be incarcerated. The author has observed several cases of this kind.

In **Acute miliary tuberculosis**, the appearances are altogether different from those of tubercular peritonitis. The tubercles are very small grey nodules hardly visible to the naked eye and specially abundant in the upper part of the abdomen and in the omentum. They are in connection with the blood-vessels and not on the surface of the membrane, being really subperitoneal, and there is no inflammation.

5. **Tumours of the peritoneum.**—These are rarely primary. **Lipomas** of small size originating from the appendices epiploicæ are common. They are usually pedunculated and of small size. The tumour may become detached by narrowing and separation of its neck and subsequently acquiring adhesions, may form a sessile tumour elsewhere, as on the surface of the diaphragm. Lipomata may also originate from the subperitoneal adipose tissue, and may attain large dimensions. They conform to the type of **Diffuse Lipomas.** Nolan removed one which weighed five pounds from over the descending colon of a child 2½ years old. **Cysts** are occasionally met with in the mesentery and omentum. **Retro-peritoneal sarcoma** is not uncommon. The tumour, sometimes growing to a very large size, pushes the organs before it and may infiltrate them.

Sometimes we meet with bulky gelatinous tumours in the abdomen, and the recognition of the exact nature of some of them is a matter of considerable difficulty. Colloid cancer of the stomach and intestine not infrequently, as we shall see afterwards, passes on till it reaches the peritoneum, and may result in the formation of bulky gelatinous masses there. But, besides that, there are primary tumours of the peritoneum which belong to the class of **Cylindroma** or **Plexiform angiosarcoma**. In these cases there is a new-formation of blood-vessels in the adventitia, of which a peculiar gelatinous tissue is produced. These tumours may attain a large size, weighing as much as forty pounds.

Primary cancer occurs with similar characters to that of the pleura, and like that form it is sometimes called endothelioma. The tumour is in the form of nodules of large or small size along with great thickening of the peritoneum. There is also great serous effusion and usually also fibrinous deposition. There may be blood in the exudation.

Secondary cancer of the peritoneum will be considered in the next section.

Lympho-sarcoma is not such a common tumour here as in the mediastinum, but it sometimes originates in the lymphatic glands of the mesentery and involves all the neighbouring structures. We may thus have bulky tumours occupying the place of a portion of the mesentery and intestine, and repeating roughly the anatomical relations of these.

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E.—The Secondary Extension of Cancers of the Abdominal Organs.

We have seen in the study of the diseases of the stomach and intestine that cancer of these organs very often leads to secondary tumours in the liver and peritoneum, and it may be well to consider here more systematically what paths the infective material follows in passing from the primary tumour to the seat of the secondary growths.

The secondary growths in the liver, in the case of cancers of the organs mentioned, form in connection with the portal vessels, and there is no doubt that the material is brought to the liver by the portal vein from its radicles. But the question remains, How does the cancerous material find its way into the radicles of the portal vein? We know that in external cancers the secondary tumours occur uniformly in the lymphatic glands, and it is only after these have been long involved that the cancerous material reaches the blood.

It seems probable that cancers of the abdominal organs form no exception to this rule, and that extension to the liver is usually a late and properly a tertiary phenomenon, although the concealed and protected position of the primary tumour and of the secondary lesions in the lymphatic glands renders this difficult of demonstration.

Supposing this view to be correct, then it follows that, if a cancer of the stomach or intestine causes secondary growths in lymphatic glands whose **Veins are not radicles of the portal**, the tumours of the tertiary order would not be in the liver but in the lungs, or beyond the lungs, in organs fed by the systemic arteries.

The author met with a case of cancer of the stomach in which, instead of the glands immediately outside its wall, as is usually the case, the pre-vertebral glands were enlarged and cancerous. One of these was adherent to the wall of the inferior vena cava, and on opening this vein a little white thrombus was seen peeping out of a small branch which emerged from the large gland into the vein. There were cancerous thrombi in other veins within these glands, and on microscopic examination it was found that the cancerous tissue in the glands had largely broken up the veins, and epithelial cells were found in them along with the blood. In this case there were innumerable cancerous emboli in the lungs.

This case would seem to indicate that cancers in lymphatic glands, by breaking up the gland, penetrate into the venous radicles in the gland, and so pass into the general circulation. It seems a legitimate inference from this case that when the liver becomes involved in cancer of the alimentary canal, it does so by the portal blood becoming infected through the lymphatic glands.

There remains one possible difficulty in the way of accepting this view. In external cancers it is exceptional for the general circulation to become infected. The disease generally goes no further than the lymphatic glands, whereas in cancers of the abdominal organs the liver is affected in a large proportion of the cases. But in cases of external cancer the patient usually suffers from ulceration of the primary or secondary growth or of both, and dies before the infection has reached the general circulation. In the case of abdominal cancers, however, the organs themselves, and the lymphatic glands, are protected by their position, and the cancers are not so apt to interfere with the general health as external cancers are. If the history of even an extensively ulcerating cancer of the stomach be compared with that of a cancer of the mamma, the difference will be very apparent. If the cancer of the stomach does not produce vomiting or stricture of the pylorus, there may be for a long period very little disturbance of the general health, and little more than symptoms of dyspepsia. It seems probable, from the history of some cases, that a cancer of the stomach may go on for many years without causing death. The abdominal lymphatic glands are still more protected. They practically never ulcerate, and, in relation to direct injury to health, cancer in them is of little account.

It seems probable, then, that in cases where the liver is affected the disease is of much longer duration in its primary seat than is often suspected. Cases of multiple cancer of the liver are often examined after death, in which no suspicion has existed during life of the existence of a primary tumour in the stomach, and this tumour may possibly have been going on for a period whose duration cannot in any way be estimated.

Cancerous infection of the peritoneum, like that of the liver, occurs by extension of cancer from the abdominal organs. The seat of the cancer may be any of the abdominal organs ; the peritoneum becomes infected when the cancerous material finds its way into the cavity.

There are some cancers which have comparatively little tendency to extend along the lymphatics to the glands, but prefer to insinuate themselves among neighbouring structures, and advance by continuity of tissue. This applies especially to **Colloid cancer,** which often grows through the wall of the stomach or intestine, while the glands are hardly at all affected. We can understand that a cancer with such a rigid stroma as this form has, and with cells which so readily swell up and become transformed, will not readily allow of transportation of its elements. But this form of cancer very readily, after growing through the wall of the stomach or intestine, infects the peritoneum, and there is no form of cancer which, in such a large proportion of cases, produces secondary tumours there.

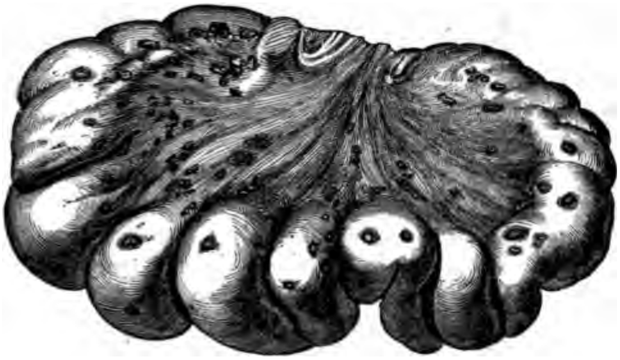

Fig. 628.—Disseminated cancer of the peritoneum, from cancer of the stomach. (VIRCHOW.)

The **Cancers of the ovary** being already very close to the peritoneum, readily produce cancerous infection, and do so in almost every form of cancer. Cancers of the **Pancreas** also frequently have a similar course for the same reason. The ordinary cancers of the alimentary canal more rarely pass through the walls and infect the peritoneum, but they sometimes do. It is besides not uncommon to meet with secondary cancers of the **Liver** which have produced an infection of the peritoneum, some of the tumours of the liver having reached the surface and extended through the capsule.

When the cancerous material gets into the peritoneum it is carried throughout it by the circulating fluid, aided by the movements of the intestine, and secondary cancerous tumours commonly spring up in the most diverse regions (Fig. 628). It may be remembered that in the peritoneum there are innumerable open stomata ready to absorb any finely divided solid matter that may be suspended in the peritoneal fluid. The infective material will therefore be carried from the surface into the substance of the peritoneum, or into the subperitoneal tissue, and the resulting tumours are really beneath the surface. They form usually flat growths with a smooth surface, the general surface of the peritoneum being perhaps unbroken. Not infrequently the tumours are continuous with one another in some parts of the abdominal wall, a layer of cancerous tissue appearing like a subperitoneal thickening.

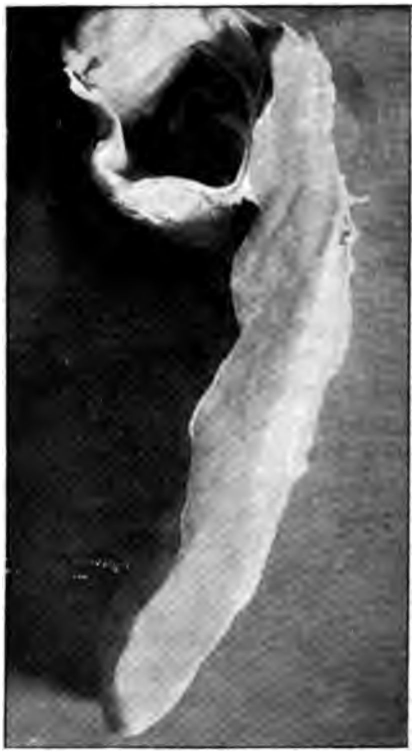

Fig. 629.—Section through the transverse colon and great omentum in a case of colloid cancer. The omentum is converted into a thick, bulky mass.

The **Great omentum** is somewhat peculiarly situated in this respect. We have seen that it probably acts as a kind of drain in the peritoneal cavity, and if this be the case it will specially absorb any material which gets into the cavity. In accordance with this there is usually in cancer of the peritoneum great new-formation in the omentum. In colloid cancer it sometimes assumes the form of a bulky heavy mass (see Fig. 629), and in other forms we have it gathered up and converted into a solid tumour lying transversely in the abdomen. We may venture the statement that this fact is too little known among physicians, and that a great omentum thus altered is frequently taken during life for an enlargement of the liver, or a primary tumour of some obscure kind.

The **Appendices epiploicæ** are also, apparently, highly absorbent, and cancerous tumours are sometimes found in them.

The relation of peritoneal cancers to the **Diaphragm** presents some points of interest. We have seen that the diaphragmatic lymphatics communicate with the peritoneal sac on the one hand, and the pleural sac on the other. In peritoneal cancers the diaphragm is usually permeated with cancerous growths, and these are often in the form of cords as if following the course of the lymphatics. In time they extend to the pleural surface, and tumours may appear there. If there are no pleural adhesions in this region the infective material passes into the pleural cavity, and numerous tumours are often found, especially in the lower parts of the pleura. A pre-existing adhesion of the diaphragm to the lung prevents this extension of the cancer.

SECTION IX.

DISEASES OF THE URINARY ORGANS.

A. **The Kidneys and Ureters.—Introduction.** 1. Structure, 2. Normal function. 3. Pathological variations in function, (*a*) diminution in urea, (*b*) uræmia, (*c*) albuminuria. I. **Malformations and Misplacements**—1. Congenital malformations. 2. Variations in position, chiefly the movable and the floating kidney. II. **Disorders of Circulation,** chiefly hyperæmia, embolism, and hæmorrhage. III. **Hypertrophy,** mainly compensatory. IV. **Hydronephrosis.** V. **Bright's disease**—1. Causation. 2. Forms, (*a*) Parenchymatous or tubular nephritis; changes in glomeruli, epithelium, etc.; the large white kidney; the contracted fatty kidney; (*b*) Interstitial nephritis; changes in interstitial tissue, tubules, glomeruli, etc.; cystic formation. 3. Character and origin of tube casts. 4. Functional changes and other phenomena; state of urine; increased arterial tension, and hypertrophy of left ventricle; œdema and dropsy, etc. Theory of vascular changes. VI. **Embolic Inflammations. Metastatic abscesses.** VII. **Inflammations of the pelvis and of the Kidney in association with the Pelvis.** 1. Pyelitis. 2. Pyelonephritis. 3. Pyonephrosis. VIII. **Retrograde changes**—1. Amyloid disease, its various origins; mostly with interstitial nephritis, 2. Atrophy, sometimes local from affection of arteries, 3. Parenchymatous infiltration. IX. **Concretions and Calculi;** in the new-born and in adults. X. **Syphilis and Tuberculosis;** chiefly local tuberculosis or renal phthisis. XI. **Tumours**—Cysts, including cystic degeneration; Sarcomas and cancers. XII. **Parasites.**

B. **Urinary bladder and Urethra.** 1. Congenital malformations. 2. Perforation and rupture of bladder. 3. Dilatation and hypertrophy, including diverticula; 4. Disorders of circulation. 5. Inflammation of bladder (Cystitis), chiefly from decomposition of urine. 6. Tuberculosis. 7. Tumours. 8. Parasites. 9. Concretions and calculi; their various forms, etc. **Diseases of the Urethra,** chiefly Gonorrhœal inflammation, and stricture.

A.—THE KIDNEYS AND URETERS.

INTRODUCTION.—In studying the diseases of the kidneys, it is necessary to bear constantly in mind the general facts as to their structure, otherwise the examination of the organs will lead to confusion. The functions of the kidney must also be understood in their outlines in order that the changes wrought by disease may be comprehended.

The normal kidney measures about 4 inches in length, 2½ in breadth, and 1¼ in thickness. The weight varies considerably, the average for the male being 4½ to 5 ounces, and for the female slightly less. The surface is smooth and the capsule, although closely applied to the surface, can be readily stripped off. On section the tissue is seen to be very regular, the distinction of pyramids and cortex being well defined.

1. **Normal structure.**—When a section of the kidney, including both cortical and pyramidal substances, is examined microscopically, the difference in the two regions is seen to be mainly due to the irregular and convoluted course of the uriniferous tubules in the cortical portion.

If attention be confined to the cortex it will be seen, as in Fig. 630, that convoluted tubules are not the only kind present. There are also straight tubules prolonged up from the pyramids in the form of tapering bundles (*a*) between which lie convoluted tubules (*b*). These tapering bundles—the medullary rays or pyramids of Ferrein—do not reach the surface, the most superficial part of the cortex presenting a continuous layer of convoluted tubules. In this way the deeper parts of the cortex present a regular division into alternating areas of straight tubules or medullary rays, and convoluted tubules. Among the convoluted tubules lie the Malpighian bodies or glomeruli (*e* in figure). These occur somewhat frequently, and at tolerably regular intervals.

In addition to these arrangements of the tubules, the blood-vessels must receive attention. The larger arteries (*d*, Fig. 630) run between pyramids and cortex, and send up stems given off at right angles into the cortex. These pass at intervals into the region of the convoluted tubules, and as they ascend they give off lateral branches to the glomeruli. It will thus appear that the areas of convoluted tubules are also the areas of the ascending arteries (which are also called interlobular arteries) and glomeruli. In the glomerulus the afferent vessel breaks up into a congeries of capillary vessels, called the tuft. These gather together to form the efferent vessel, and this again breaks up into capillaries which surround the tubules with a rich network.

The large arteries which run between the pyramidal and the cortical portions also give off occasional lateral branches downwards to the pyramids. These arteries break up into bunches of straight arterioles (arteriæ rectæ, *c* in Fig. 630) which are increased by branches coming down from the afferent vessels in the deeper parts of the cortex. These bunches of arterioles taper as they pass down the pyramids, so that they form small pyramids with their bases towards the cortex. They correspond in position with the areas of convoluted tubules, which areas they, as it were, prolong down into the pyramids.

2. **Function.**—In studying the functions of the kidneys we have to remember in the first place the course of each uriniferous tubule, which may be followed in the annexed diagram (Fig. 631). It begins in the Malpighian body (I). Issuing thence the tubule becomes convoluted (II), and then dips down in a long loop (Henle's loop) whose bend *h* is usually in the pyramidal portion. Turning upwards (IV) the loop comes back to the cortex, again becomes convoluted (V), and then opens sometimes at an acute angle, into a straight tubule (VI) which passes directly downwards, joined by other tubules (VII), till it opens at the apex of the pyramid (IX) into one of the calices.

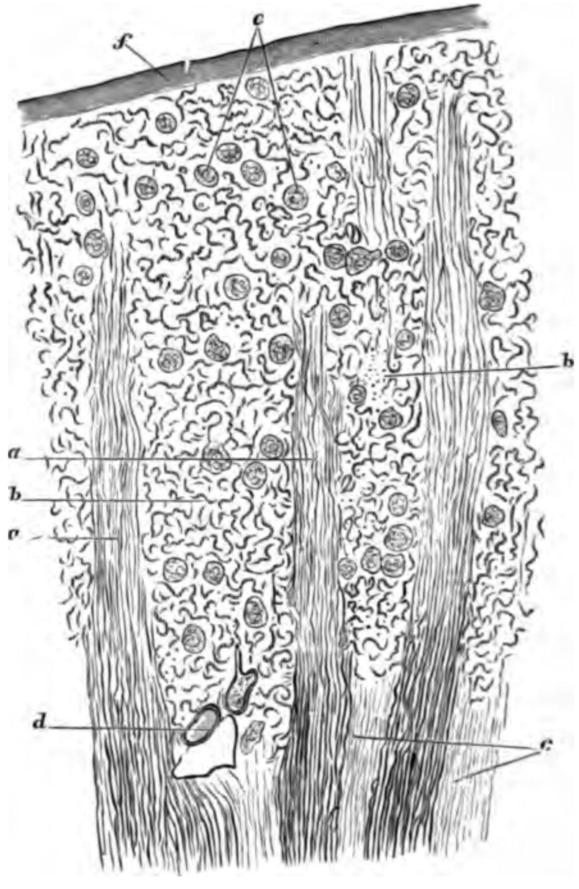

Fig. 630.—Section of normal kidney including cortex and base of pyramid with a very low magnifying power. *a*, medullary rays; *b*, convoluted tubules; *c*, region of arteriæ rectæ in pyramids; *d*, larger vessels running between pyramid and cortex; *e*, Malpighian tufts; *f*, capsule. × 12.

So far as the water of the urine is concerned, it is generally agreed that it passes from the blood at the glomeruli; it filters, in fact, from the capillaries into the ends of the tubules. According to Bowman's view, it is mainly the water which passes through at the Malpighian bodies, the urea, urates, etc., being secreted from the blood by the large granular epithelium which lines the convoluted tubules.

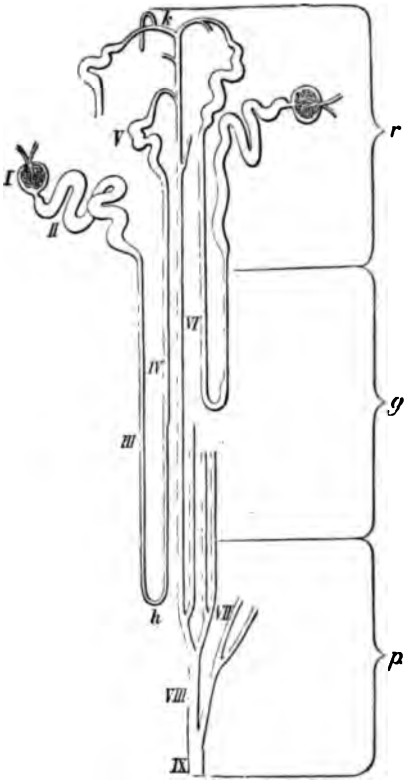

Fig. 631.—Diagram of course of uriniferous tubules from Malpighian body (I) to pyramid (IX.) See text. (QUAIN.)

It seems probable that Ludwig's view is correct, that the water passing through at the glomeruli is partly reabsorbed, but that the function of the epithelium is not confined to this. In experiments, in which indigo-sulphate of sodium was injected into the blood, it was found that this substance was excreted by the epithelium of the tubules, chiefly that of the convoluted tubules. The colour of the substance rendered it possible to see the seat of its excretion. As an inference from this it may be supposed that the epithelium is actively engaged in separating urea and other urinary constituents, perhaps changing some of them in transit.

The actual amount of the urine secreted will depend on the blood-pressure in the vessels of the glomeruli and on the quantity of blood passing through these vessels. The amount secreted will be increased by increase of pressure in the vessels provided that the amount of blood is not thereby largely decreased, and it will be diminished by any cause which markedly diminishes the pressure in these vessels. Considering the close relationship of the renal vessels to the systemic arteries and veins, it is clear that the blood in the former will be liable to considerable variations in pressure and in the speed of the current from circumstances affecting the general circulation, such as disease of the heart and lungs.

3. **Pathological variations in function.**—In considering the various forms of disease of the kidneys it is necessary to consider their influence

on the functions of these organs. There are two principal pathological changes in function which merit more particular consideration, namely, diminution in the amount of urea and albuminuria.

(*a*) **Diminution in urea and other excreta.**—The secretion of urea (and other excretory products of less known composition) is chiefly, as already mentioned, a function of the renal epithelium. It has also been indicated that the secretion of water is effected in the glomeruli, so that these two functions are exercised in different situations and may be variously altered without relation to each other. The amount of water may be greatly in excess, whilst the percentage of urea in the urine may be so small that the total daily amount is greatly under the normal. It may be said that relaxation of the renal arteries with increase in the general blood-pressure by increasing the amount of blood passing through the kidneys, will directly increase the amount of water separated in the glomeruli, and will also stimulate the separation of urea should there be an excess of the latter in the blood. But, if the renal epithelium be lost or paralysed, there may be a great diminution in the urea excreted, even though the water is greatly increased. Loss of the epithelium tends in another way to produce a watery condition of the urine, as the function of the epithelium in concentrating the urine will be diminished. It may thus be inferred that while interference with the circulation of the kidneys by stagnation of the blood or otherwise, is likely to diminish both the water and urea, interference with the epithelium diminishes the amount of urea whilst not diminishing the secretion of water.

(*b*) **Uræmia.**—The subject has already been referred to in the general part of this work This term is applied to a group of symptoms, the principal of which are vomiting, sleeplessness, headache, convulsions and coma, which are liable to occur when the excretion of the essential urinary constituents is seriously diminished. These constituents retained in the blood act as poisons, but it has not been found possible to discriminate amongst the various symptoms as to how they are related to the different constituents of the urine, the chief of which are urea, creatine, and creatinine. Urea, at least, is not a vigorous poison, and it seems to be only when in great excess and acting for a considerable period that uræmic symptoms are produced.

There are two different ways in which the urinary constituents may be caused to accumulate in the blood. The excretory apparatus in the kidneys may be diseased in the manner referred to above ; in particular the secreting epithelium may be interfered with. But the outflow of urine may be hindered by obstruction to the urinary passages. In this latter case there is to some extent a re-absorption of the urinary constituents, but as the ureters and pelves become distended by the accumulating urine the secretion in the kidneys gradually ceases (see under Hydronephrosis), so that the constituents are retained in the blood. It will be understood that whilst uræmic symptoms most readily develop when the urine is diminished or suppressed either by disease of the kidneys or by obstruction to the outflow, its occurrence is not inconsistent with even an excess of watery urine.

Considerable doubt was at one time thrown on the view that the symptoms of uræmia were due to poisoning by the urinary constituents. The injection of urea or urine into the blood of animals, or the ingestion of urea with the food, led only to an excessive secretion of urine and failed to produce the symptoms. Two theories were devised to account for these apparent discrepancies. The theory of Traube, that the symptoms are due to œdema of the brain, is not now accepted. Nor is that of Frerichs, according to which it is not the urinary constituents themselves, but the products of their decomposition, chiefly carbonate of ammonia, which act as poisons. Chemical investigation shows that there is no excess of carbonate of ammonia in the blood in uræmia, and experiment indicates that carbonate of ammonia when introduced into the blood produces symptoms different from those of uræmia.

It is the **accumulation** of the constituents in the blood which produces, after a time, an intolerance of them. If, besides injecting urine into the blood in animals, the ureters be ligatured, then the symptoms of uræmia rapidly manifest themselves.

(*c*) **Albuminuria.**—By this term is meant the escape of the serum-albumen along with the water of the blood, which no doubt occurs at the glomerulus. The albumen probably undergoes some changes after or during its passage (Kirk). Albumen is found in small quantities in the urine of some persons apparently healthy, so that a condition of so-called **Physiological albuminuria** has been distinguished. There are, however, in such cases, only slight traces, and the presumption is that some disturbance actually exists in the kidneys in all cases of albuminuria. It is clear from the variety of conditions which may lead to it that it may be induced by a comparatively slight derangement.

The water of the urine is eliminated, as already mentioned, mainly at the glomeruli by a process which has been compared to filtration. If it were a simple filtration, albumen would be present, and some observers have supposed that albumen does pass through, to be re-absorbed by the epithelium of the uriniferous tubules. It is generally acknowledged that water is re-absorbed in the tubules, and that the urine is thus concentrated, but the re-absorption of albumen is much more problematical. Such a hypothesis would imply that the appearance of albumen in the urine was due to the failure of the epithelium to absorb, and we should expect it to be associated with an excess of water.

Precisely the opposite is in general the case, and albumen is more frequent in concentrated than in dilute urine.

The truth seems to be that the process in the glomeruli is not a simple filtration, but a transudation through a living membrane of complicated structure. Wherever such transudations occur in the living body there is some selection of the constituents which are allowed to pass, and although the transudation-fluids are albuminous they are so in very varying degrees. Thus the percentage of albumen in cerebro-spinal transudations is about 1·5 per cent., whereas in the peritoneal and pleural cavities it may be five or ten times as great (see p. 105). The glomerulus is more like a secreting or glandular organ than a simple filter. The water in passing out has to penetrate the walls of the vessels and then a layer of epithelium. The capillary vessels themselves are highly cellular, being very abundantly nucleated, and the epithelium clothes the tuft completely (Heidenhain). These structures exercise a selection in allowing the passage of the constituents of the blood, giving transit especially to water and salts. It is a very interesting fact, and one entirely confirmatory of this view, that while serum-albumen is retained, egg-albumen when injected into the blood of animals is passed into the urine. (Stokvis and others.) Any derangement of the delicate glomerulus is likely to allow of the passage of albumen, and it will be found that diseases which specially affect this delicate organ, such as acute inflammation and amyloid disease, are specially characterized by albuminuria.

It is not improbable that albumen may reach the urine from other sources than the glomeruli. The arteriæ rectæ of the pyramids occupy a somewhat similar position in the vascular system to that of the glomeruli. They come off to a large extent directly from the larger arteries, and the blood after leaving them also passes into capillaries. It is noticeable also that they and the glomeruli are the structures first and chiefly affected by amyloid disease. It is not improbable that in inflammations and in amyloid disease there may be considerable transudation of serous fluid from these vessels, which may find its way into the uriniferous tubules.

Literature.—See full account in Heidenhain, in Hermann's Phys., v., 1880; Pantyuski, Virch. Arch., lxxix., 1880; Traube, Ges. Abhandl., 1871; Frerichs, Die Brightsche Krankh., 1851; Cohnheim, Gen. Path., Syd. Soc. transl., iii., 1890; Stokvis, Recherches expér. sur l'albuminurie, Journ. de Soc. Roy. de Bruxelles, 1867; Kirk, Glas. Med. Jour., xv., 1881; Heidenhain, loc. cit.; Senator, Die Albuminurie, 1882; Discussion on Albuminuria in Path. Soc. of Glasg. (by Roberts, Hamilton, Gairdner, Greenfield, Newman, Coats, etc.), Glasg. Med. Jour., 1884; Discussion on Diuretics in Brit. Med. Assoc. (by Barr, Marshall, etc,), Brit. Med. Jour., ii., 1897; Hellin and Spiro, Arch. f. exper. Path. u. Pharm., xxxviii., 368; Magnus, ibid., xliv., 396; Cushny, Jour. of Physiol., xxvii. and xxviii., 1902.

I.—MALFORMATIONS AND MISPLACEMENTS OF THE KIDNEYS.

1. **Congenital malformations.**—These are frequently such as to produce comparatively little interference with the function of the organs. This does not apply to the extreme cases where both organs are absent or extremely small. This only occurs with serious malformations of the body as a whole, and the child does not survive.

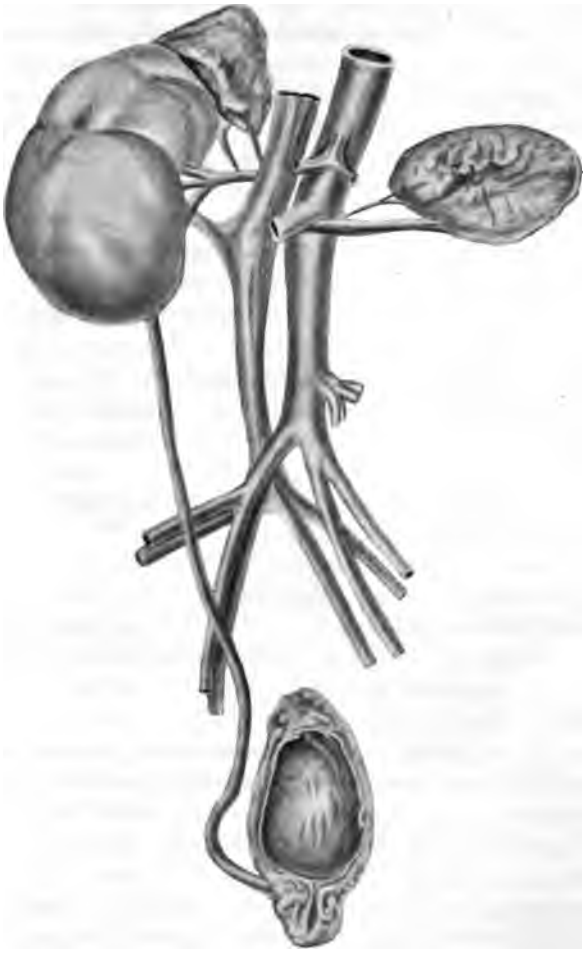

Fig. 632.—Entire defect of the left kidney in a young child. Compensatory hypertrophy of the right kidney.

Defect of one kidney is not infrequently met with in well-formed adults without any sign of disease of the kidneys (Fig. 632). It is mostly the left kidney that is defective, and it may be entirely absent, its vessels and a diminutive ureter ending in a piece of connective tissue. The other kidney in these cases undergoes a compensatory hypertrophy.

The kidney also not infrequently shows some trace of the **Fœtal lobulation** which in some animals is normally retained throughout life (see Fig. 633).

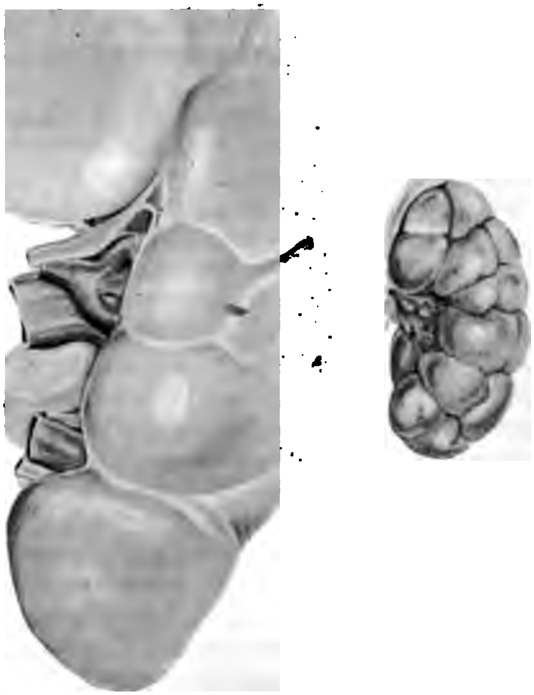

Fig. 633.—Fœtal lobulation of adult kidney with fœtal kidney for comparison.

Coalescence of the two kidneys across the middle line is one of the most frequent malformations. Various degrees of it are seen. It may be a simple elongation of the inferior extremities of the kidneys which are united by a fibrous band passing across the vertebræ. Or there may be a proper isthmus of renal tissue uniting the two kidneys into one and forming the well-known **Horse-shoe kidney** (Fig. 634). From this we have various grades on to complete coalescence of the kidneys into an elongated or square body across the vertebræ. In Fig. 635 is shown a not uncommon form—the **Sigmoid kidney**. In

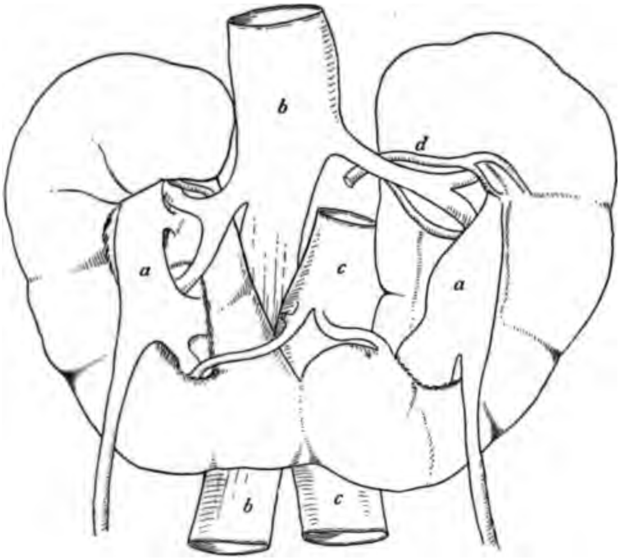

Fig. 634.—Horse-shoe kidney. *a*, *a*, pelves with ureters, the latter coming off from the external instead of the internal borders; *b*, *b*, vena cava; *c*, *c*, aorta giving off two renal arteries; another artery, *d*, came off higher up.

almost every case there are two ureters, but they may be increased in number. This form of kidney is often depressed in position, even coming as low in some cases as the hollow of the sacrum. When depressed the arteries usually have abnormal origins, as from the common iliac, hypogastric arteries, etc.

2. **Variations of position.**—These may be congenital or acquired. In the former case and in some of the latter the kidney is fixed in its unusual situation. In **Congenital malposition** it is generally the left kidney which is concerned. It may be depressed so as to lie as low as the brim of the pelvis or even in its

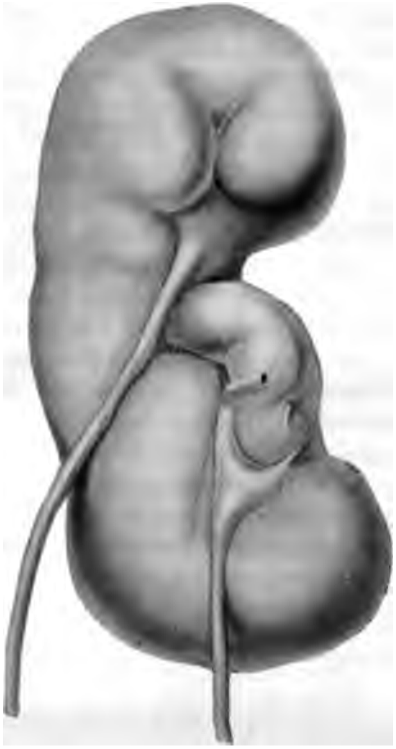

Fig. 635.—The sigmoid kidney.

cavity (Fig. 636). It is not infrequently seated opposite the sacro-iliac synchondrosis. Such kidneys have usually the hilum presenting

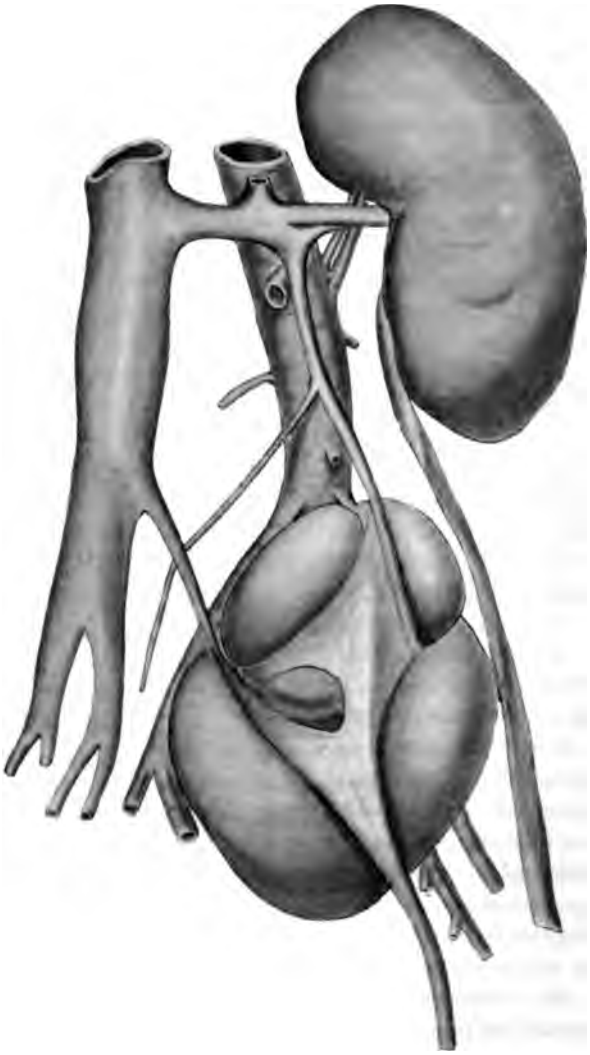

Fig. 636.—Malposition and malformation of the right kidney.

forward, and are flattened; their vessels are branches of the lower end of the aorta and of the iliac veins, or even entirely of the iliac vessels. The kidney may also lie nearer the middle line than normal or in the middle line.

The malposition may be acquired by the pressure of tumours or of the liver, by the dragging of a hernial sac, and so on.

Movable and Floating kidney.—These terms designate two conditions, both of them characterized by undue mobility of the organ. The kidney normally lies behind the peritoneum, which covers it only on its anterior surface. The organ, being in the loose retro-peritoneal tissue, is surrounded by a fatty capsule as well as by its more immediate connective-tissue capsule. It is fixed to the posterior wall of the abdomen by its vessels, partly by the peritoneum binding it down, and partly by the pad of adipose tissue which forms its fatty capsule.

In the **Movable kidney** the organ is unduly mobile behind the peritoneum ; it may be movable within its fatty capsule or may carry this with it in its displacement. It is sometimes greatly displaced up under the ribs, down into the pelvis, or for a short distance across the middle line, although usually the mobility is limited.

The undue mobility occurs in the great majority of cases in females, and it is usually on the right side (in the proportion of 152 : 12; see Newman). Its frequency in women is ascribed to the disturbances produced by pregnancy, and also to the wearing of stays. The relations of the right kidney to the liver and ascending colon probably account for the greater frequency on this side. The heavy liver, especially when pushed downwards by stays, may dislocate the kidney, and the ascending colon is more loosely attached on the right side of the abdomen than is the descending colon on the left. Rapid emaciation, by diminishing the pad formed by the fatty capsule, is not an infrequent cause. It is stated that there may be a local diminution of the fat in the capsule.

Floating kidney is, strictly, a kidney with a meso-nephron. The peritoneum covers both surfaces of the organ, and forms a mesentery which contains the vessels. This form is excessively rare, and its existence has been denied by some. It is of congenital origin. The degree of mobility is not greater than in many cases of movable kidney, and the two conditions are scarcely distinguishable during life.

The movable kidney is not very liable to secondary changes, although sometimes the abnormal position interferes with the flow through the ureter, and leads to hydronephrosis, or even inflammation of the pelvis. Of more importance is the fact that by dragging there may be serious nervous disturbances in the form of excruciating cramps. The kidney may, however, be movable without any such nervous symptoms presenting themselves.

3. **Malformations of the ureters and pelvis.**—These are, in general, of little importance. The ureter may be double either in its whole course or in its upper part. The pelvis may also be double or in several divisions, each of which has a separate connection with the ureter. The ureter may arise from the pelvis at an acute angle, or

there may be a kind of valve in the course of the ureter from a fold of mucous membrane.

Literature.—Rayer, Traité des malad. des reins, iii.; Förster, Die Missbildungen; Lancereaux, L'Union méd., 1880; Landau, Die Wanderniere d. Frauen, 1882; Reports of Committee, Path. Trans., xxvii., 1876; Newman, Surgical dis. of kidney, 1888; Boström, Path. Anat. der Niere, 1886; Sutherland and Edington, Glas. Med. Journ., i., 1898, and Glas. Hosp. Reports, iii., 1901; Morris, Surg. Diseases of Kidney, 1902; Jores, Lubarsch & Ostertag, Ergebnisse, vi., 1901.

II.—DISORDERS OF THE CIRCULATION IN THE KIDNEYS.

Active hyperæmia is caused by dilatation of the renal arteries. This may result from traumatic injury to the vaso-motor centre in the medulla oblongata. In a case of this kind observed by the author there was the most intense hyperæmia with enlargement of both kidneys, the injection affecting all the vessels. During the few hours that the patient survived large quantities of urine were twice removed by the catheter, and after death the bladder was again found distended by a watery urine. Again, we may have an active hyperæmia from removal of pressure, as after excision of large tumours from the abdomen or the removal of ascitic fluid, or even the removal of fluid from the pleura. Under these circumstances there is often for a day or two excessive secretion of urine lasting till the renal vessels resume their normal state of contraction.

The hyperæmia which follows on the administration of certain poisons, such as cantharides, arsenic, and carbolic acid, is to be regarded as really inflammatory.

Passive hyperæmia results from obstruction to the venous circulation, and is most frequently met with in valvular disease of the heart and in diseases of the lungs in which the circulation is seriously interrupted, as in severe emphysema.

If the obstruction take place suddenly there may be very intense engorgement of the renal vessels and considerable hæmorrhage from the glomeruli, so that their capsules and the tubules contain blood.

In the more usual chronic cases, such as occur so frequently in cases of heart disease, the kidneys present an increase in density due to **Cyanotic induration** (see p. 72). There is also a general redness, but this is usually most manifest in the pyramids where the arteriæ rectæ often show very special dilatation, indicated by exaggeration of the red streaks which pass from the bases of the pyramids in the direction of the apices. The glomeruli are also visible in the cortex as small red spots. In congenital cardiac affections the condition is often extreme (see Fig. 637).

Microscopic examination shows great overfilling of the vessels, accompanied in many cases with atrophy of the epithelium of the tubules, which is not infrequently fatty. There is often blood in the glomeruli and tubules, and sometimes brown pigment which has formed from the blood. This pigment may be partly crystalline. The tubules also frequently contain hyaline tube-casts.

Thrombosis of the renal veins is sometimes a result of passive hyperæmia, but it usually occurs just before death and when the patient is very much debilitated. The author met with it in a case of amyloid disease which had followed on an attack of gonorrhœal rheumatism.

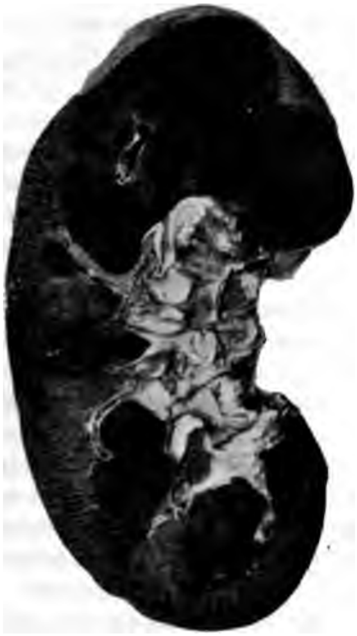

Fig. 637.—Passive hyperæmia of kidney in congenital cardiac disease.

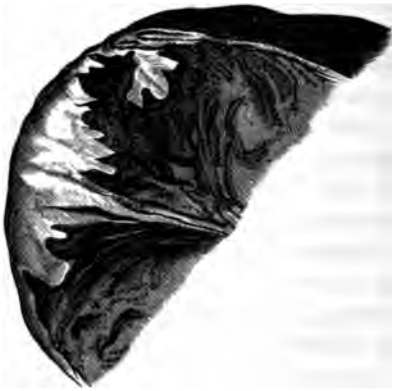

Fig. 638.—Embolic infarction of the kidney. The white appearance and wedge shape of the infarction are represented. (After RAYER.)

Embolism of the kidney is very frequent. Remembering that the renal arteries are strictly end arteries, it will be understood that when one of them is obstructed **Infarction** virtually always occurs. The arteries of the kidney being distributed primarily to the cortex, the infarction is more or less wedge-shaped (Fig. 638), with the base of the wedge at the surface. If the wedge be of larger size it will extend also into the pyramids.

As a rule the infarction is of a pale colour and of dense consistence, the tissue having undergone **Coagulation-necrosis.** There is not generally much hæmorrhage, but usually at the margin there is some, and if the infarction be small the hæmorrhage may extend throughout it. Around the infarction there is a zone of hyperæmia.

The kidney tissue seems to undergo necrosis very readily when deprived of blood. Litten found that when the renal artery was ligatured for two hours the renal epithelium was already necrosed. This is probably the reason why the infarction seldom takes the hæmorrhagic form. The readiness with which the renal epithelium dies is frequently shown in infarctions of the kidneys, and is illustrated in Figs. 204 and 205, p. 373. At the peripheral parts of the infarction, and in small ones throughout it, the epithelium may be found dead, as evidenced by the absence of nuclear staining, whilst the connective tissue remains alive, having its nuclei fully stained.

The infarction gradually undergoes absorption, and is replaced by a cicatrix. In this way deep depressions of the kidney may occur, and if there are several of them the kidney may assume a lobed appearance. In cases of old mitral or aortic disease it is very common to find deep cicatrices, indicating that, probably at the time of acute endocarditis, embolism of the kidney had occurred.

The kidney is not infrequently the seat of **Septic embolism** in pyæmia, ulcerative endocarditis, etc. (see Fig. 46, p. 157, and Fig. 330, p. 524). The result is the formation of miliary abscesses, which will come up for consideration hereafter.

Hæmorrhage from the kidney is very frequent and important. It is of common occurrence in acute nephritis, and is not infrequent in chronic. It is a frequent symptom in tumours of the kidney, especially in cancers and cystic degeneration, and it results from calculi in the pelvis of the organ.

Purpura and scurvy seem to have a special tendency to affect the pelvis of the kidney, causing bleeding from its mucous membrane. A peculiar and interesting form is met with in infants, in whom a scorbutic condition has been induced by artificial feeding without sufficient fresh milk. In this case blood in the urine may be the only direct symptom of scurvy. (See Dickinson.)

When the hæmorrhage is from the kidney proper the blood is intimately mixed with the urine, as in Bright's disease and scurvy. When the bleeding is from the pelvis as from calculi, tumours, etc., the blood is often coagulated, and when found in the urine it sometimes has an elongated worm-like form acquired in passing through the ureter. This passage causes much pain. Hæmorrhage into the parts around the kidney will only occur in cases of rupture from injury of the organ.

Literature.—Cohnheim, Die embol. Process, 1872, and Allg. Path., ii.; Litten, Hæmorrh. Infarc., 1877, and Virch. Arch., lxxxviii., 1882; Recklinghausen (Retrograde embol. of renal vein), ibid., c., 1885; Dickinson, Renal and urinary affections, part iii., 1885; Jores, loc. cit., 1901.

III.—HYPERTROPHY OF THE KIDNEY.

Compensatory hypertrophy of the kidney readily develops when one kidney is lost or congenitally defective. In the case of congenital absence of one kidney the other will be found homogeneously enlarged and weighing nearly the same as the two normal kidneys together (see Fig. 632). The different regions of the kidney bear the same relations to each other, each being enlarged in its due proportion. The function of the kidneys is also completely carried out by the single one.

It has been determined by experiments in animals that compensatory hypertrophy develops after excision of one kidney in full-grown animals, although it is more complete when the operation is done in the newborn. It is remarkable how soon after such excision complete restoration of the renal functions occurs, the secretion of urea having reached its normal in one case about two days after the operation, and the animals having remained from the first apparently unaffected in health.

In the hypertrophied kidney there is new-formation of tissue. There is not, however, a numerical increase in the lobules of the kidney, the glomeruli not being increased in number, although slightly in size. As the capsules are the expanded ends of the tubules, the latter also are not increased in number. They are not even increased greatly in diameter, and the hypertrophy seems to consist chiefly in an elongation and increased convolution of the tubules, with great new-formation of epithelium.

Besides this form of compensatory hypertrophy, there may be an enlargement of both kidneys in diabetes insipidus, and perhaps also in diabetes mellitus.

Literature.—Rosenstein, Virch. Arch., liii., 1871; Gudden, ibid., lxvi., 1876; Grawitz and Israel, ibid., lxxvii., 1879; Beumer, ibid., lxxii., 1878; Coats, Proceedings Med. Soc. of London, vii., 1884; Sacerdotti, Virch. Arch., cxlvi., 1896; Aschoff, Lubarsch & Ostertag, Ergebnisse, v., 1900.

IV.—HYDRONEPHROSIS.

Hydronephrosis.—In this condition there is dilatation of the pelvis and calices of the kidney, as a result of obstruction of the ureter or urethra.

Obstruction of the urethra may be congenital or acquired. In the latter case there is first dilatation and hypertrophy of the bladder, and then of the ureters and pelvis. In all such cases the hydronephrosis is double, although it is not always equal on the two sides.

Obstruction of the ureters may occur in any part of their course. Tumours or inflammatory swellings in the pelvic organs may obstruct the lower ends, and usually both ureters are affected. Calculi descending from the pelvis of the kidney occasionally cause obstruction. A peculiar form of obstruction is that in which the ureter does not, as in the normal condition, form a continuation of the pelvis of the kidney, but starts from it at an acute angle, passing obliquely through its wall. This is probably a congenital malformation. Of similar origin is probably the occurrence of valves in the course of the ureter. More unusual causes are, pressure from without by a renal artery or vein taking an unusual course so as to cross the ureter (see Fig. 639); abrupt bends in the ureter which may be congenital or may arise from the ureter making an unusually abrupt turn over the brim of the pelvis when the edge has been rendered sharper than usual by emaciation.

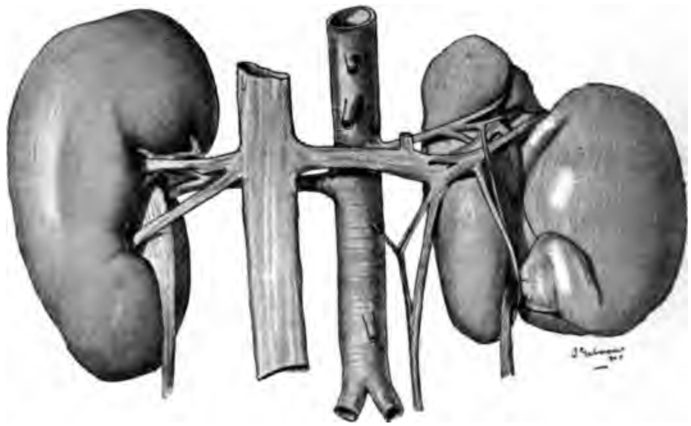

Fig. 639.—Hydronephrosis of right kidney. Aberrant renal vessels. Viewed from behind.

It appears from the last instance that a comparatively small external pressure may obstruct the ureter, and that the urine in the pelvis and ureter is at such a low pressure as to be incapable of overcoming a comparatively slight resistance.

In some congenital cases no evidence of obstruction can be found (Fig. 640).

The existence of some of these causes has been doubted, chiefly the existence of a valved aperture by the ureter arising from the pelvis at an acute angle, and the occurrence of valves in the course of the canal. There are two specimens of the former kind in the Western Infirmary Museum, Glasgow (see Catalogue), and Dr. Sainsbury has published an apparently undoubted case of the latter form. The author has also recorded a case in which a branch of the renal artery had so crossed the ureter just at its emergence from the pelvis as to produce an obstruction. Fig. 639 represents another example of the same.

According to statistics collected by Newman, the obstruction arises, in the large majority of cases, either from obstruction of the urethra or from tumours of the pelvic organs, which may involve the ureters. These causes produced hydronephrosis in 400 out of 448 cases of double, and 133 out of 215 cases of single hydronephrosis. Renal calculi form the most frequent cause of single hydronephrosis.

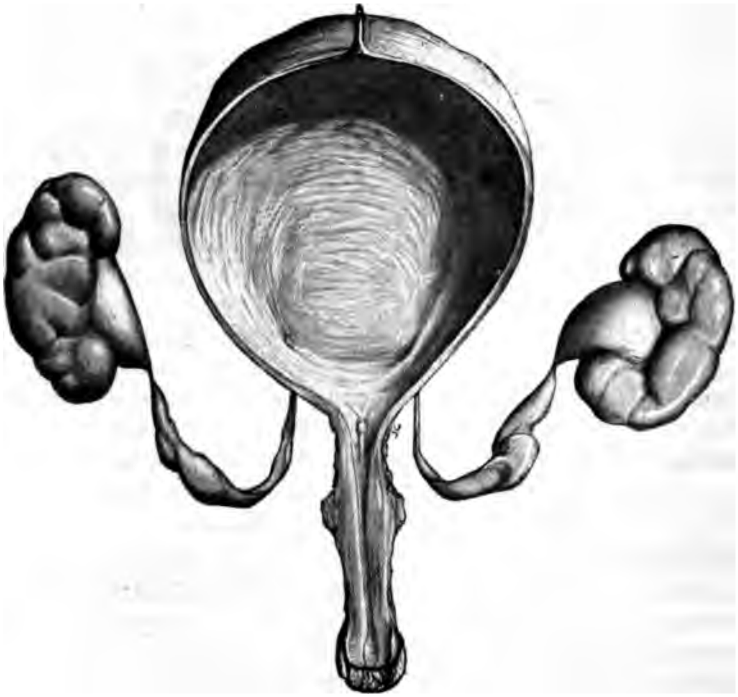

Fig. 640.—Congenital hydronephrosis with dilatation of the bladder and ureters.

The result of the obstruction is dilatation of the pelvis and calices (see Fig. 641 and Fig. 663, p. 1113), but in addition there is frequently a considerable destruction of renal tissue. That is to say, the dilatation of the calices causes atrophy, first of the papillæ which project into them, and then of the pyramidal portion of the kidney, and finally of the deeper parts of the organ. We thus sometimes find the pyramids as if cut abruptly across. But the condition frequently advances still further. The dilated calices increase in volume till, in the most extreme case, the kidney is replaced by a **Cyst** which represents dilated pelvis and calices, partitions existing in it corresponding to the divisions between the calices. When this has occurred, the cyst may go on enlarging so as to form a tumour of great bulk. The ureter is also dilated, often so greatly as to look like a piece of small intestine. It generally becomes convoluted in its course as well.

It is not in every case quite apparent what circumstances determine **the degree of hydronephrosis**. Complete obstruction leads usually to a comparatively slight hydronephrosis, the most extreme degree being reached in cases where on one side there is either an incomplete obstruction or one which gives way at intervals, such as a valved condition of the upper orifice of the ureter.

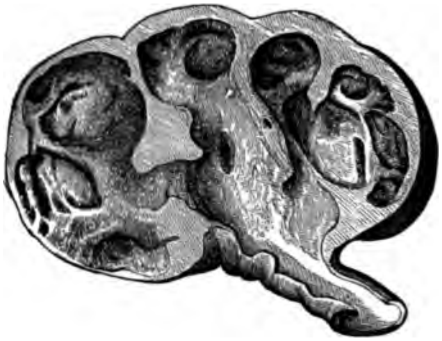

Fig. 641.—Hydronephrosis with granular atrophy of the kidney. The other kidney showed a marked compensatory hypertrophy. (Virchow.)

The ureter has been ligatured in animals and the processes observed. The first result is dilatation of the pelvis and of the ureter above the ligature. The tension of the urine in the ureter also rises up to a certain point, which, however, is far below the blood-pressure. When this point is reached the full extent of the distensile force derived from the secretion of the urine is attained. The secretion of the water of the urine, consisting in a transudation through the vessels of the glomeruli, is directly proportionate to the difference in pressure between the blood in the tufts and the fluid in the tubules, and when the pressure in the tubules is raised the secretion of urine ceases as soon as a state of equilibrium is brought about.

There are, however, two elements in the problem still to be considered. In cases where the ureter has been ligatured in animals the actual dilatation of the pelvis and calices has been comparatively slight, the state of equilibrium of tension being easily reached. And so in the human subject, when the obstruction is complete the pressure of the fluid in the dilated pelvis soon causes considerable obstruction of the renal vessels, and the power of secretion is reduced. But if, at times, an outlet is found for the urine and the pressure is suddenly reduced, there will be a relief of the vessels in the kidney and a violent hyperæmia leading to an excessive secretion of urine. As a matter of fact the sudden relief of an obstruction of the ureter has been found to be followed by an excessive secretion of urine which contained albumen. Where then there are such repeated sudden collapses and dilatations the advance of the hydronephrosis is most complete.

The fluid contained in the cavity is at first urine, but as the condition becomes fully established the urinary constituents become absorbed and a watery albuminous fluid is found. In rare cases a colloid matter or a fatty milky fluid has been observed.

It sometimes happens that where a prolonged obstruction has existed **the external fatty capsule** of the kidney is greatly thickened, while only a moderate hydronephrosis exists, *i.e.* the size of the organ is not greatly increased. It is not unlikely that an œdema of the capsule following the obstruction of the ureter may be the cause of this great accumulation of fat by affording an extra supply of nourishing fluid, or perhaps by acting as a prolonged irritant.

We sometimes meet with cases resembling hydronephrosis, but in which some of the cysts, representing dilated calices, do not communicate with the pelvis, but form **Independent cysts.** This occurs when from inflammation there has been partial or complete obliteration of the pelvis (see under Pyonephrosis).

Literature.—ROKITANSKY, Lehrb., iii.; COATS, Catal. of Western Inf. Museum, Glasgow; SAINSBURY, Path. Trans., xxxvii., 1886; NEWMAN, Lect. on Surg. dis. of kidney, 1888, and Glas. Med. Jour., vol. xxxv., 1891; MORRIS, loc. cit., 1902.

V.—BRIGHT'S DISEASE. NEPHRITIS.

The term Bright's disease is here limited to **Simple inflammations of the Kidneys,** whether acute or chronic, which are bi-lateral, and hence due to conditions of the blood. The inflammation does not occur around definite centres, and seems, therefore, to be due to substances in solution acting on the kidney tissue. The term is thus synonymous with **Nephritis,** excluding those forms of inflammation, such as septic inflammation, which are due to the local action of microbes.

1. **Causation.**—The irritant dissolved in the blood, as just mentioned, acts on both kidneys and on all parts of them. But, as the cortex contains the more active secreting tissue of the organ, and as the blood is primarily distributed to it, we find that the inflammatory manifestations occur chiefly in that region. Again in the various forms of Bright's disease we do not find the different constituents of the kidney tissue equally involved. An irritant brought to the kidneys by the blood may show a predilection for the renal epithelium on the one hand, or the connective tissue on the other. It may be said, indeed, that for

the most part irritants which act through a long period and with little intensity produce a chronic inflammation mainly affecting the connective tissue. On the other hand, irritants which act intensely so as to produce acute inflammation, while they induce the usual changes in the blood-vessels which we have seen to occur in acute inflammations, affect mainly the glomeruli and the epithelium of the uriniferous tubules. It may therefore be said that acute inflammations are mostly **Parenchymatous**, while chronic inflammations are mostly **Interstitial.**

The Nature of the irritant.—There are some forms in which the specific poison of an infective disease is the agent. Thus **Acute Bright's disease** is a frequent sequela of **Scarlet fever,** and more rarely of measles and other acute fevers. This would indicate that in other cases of acute nephritis an organic poison is the probable cause. No such agent can be definitely distinguished in a large proportion of cases. The disease is often ascribed to **Cold.** In this connection Dickinson points out that cold mostly produces nephritis when the person is exhausted or asleep, or when the exposure has occurred immediately after profuse perspiration. It is as if, the functions of the skin being suspended, some deleterious material had accumulated in the blood and irritated the kidneys. It appears that nephritis hardly occurs in persons exposed to cold in the Arctic regions, probably because, the respiration being more vigorous, the deleterious material is carried off by the lungs. In warm climates also nephritis is uncommon, probably because the body is less liable to sudden exposure to cold than in temperate regions.

As to the nature of the irritant in **Chronic Bright's disease** we have in **Gout** an irritant which is known to produce inflammation in other parts besides the kidneys. The pathology of gout is not very apparent, but there is an obvious alteration in the blood in consequence of which salts of uric acid are deposited in certain joints, generally with signs of acute inflammation. The same condition of the blood frequently induces chronic nephritis, and it is remarkable that when it attacks the kidneys it is less likely to affect the joints, and *vice versa.* Among the working classes gout largely arises from chronic **Lead-poisoning** (see statistics in Dickinson's work on Albuminuria), and in these cases the disease is particularly liable to attack the kidney, so much so that a large proportion of painters and others who work with lead die of chronic nephritis. Where gout is due to the constant use of alcohol the disease is more liable to attack the joints. Chronic nephritis is also sometimes induced by the poison of **Syphilis.** In this case it is apt to be associated with amyloid disease, but may also occur as a simple inflammation.

Pregnancy not infrequently leads to a chronic nephritis, in all probability by obstructing the vessels of the kidney by the pressure of the uterus. In recent cases there is extreme hyperæmia of the kidney, which, with repetition of the cause, may go on to assume the regular characters of chronic nephritis.

Lastly, there are cases in which there is no special cause apparent, and we can only say that the person has been exposed to some influence whose nature we do not know. In many cases the disease has been very prolonged, and, all through, the actual active disease at any particular time has been very slight. With this very insidious course, there may be the most serious permanent changes in the kidneys before any prominent symptoms have called attention to these organs.

2. **Forms of Bright's disease.**—Various subdivisions of Bright's disease have been made both from the clinical and the pathological points of view. The most generally accepted division is into parenchymatous and interstitial nephritis, to which some add the amyloid kidney.

Inflammations of the kidney have similar characters to those of other parts. In **Acute inflammations** the vessels chiefly are affected at the outset; there is hyperæmia with exudation of serous fluid, leucocytes, and red blood-corpuscles. These find their way into the tubules and interstitial tissue, and appear in the urine as albumen, leucocytes, and red blood-corpuscles. Death seldom occurs at the outset of the attack, and the appearances found post mortem are referable rather to secondary changes, chiefly in the secreting structures. Hence acute nephritis is included mainly under parenchymatous nephritis.

Chronic inflammation in the kidneys, as elsewhere, is chiefly characterized by new-formation of connective tissue, and hence is included, for the most part, under interstitial inflammation.

It is to be understood, however, that as parenchymatous and interstitial changes are by no means mutually exclusive, and indeed frequently co-exist, so also the phenomena of acute and chronic inflammation are not limited either to the one or other form.

(*a*) **Parenchymatous nephritis** (*Tubular nephritis*).—Parenchymatous nephritis is, at the outset, usually acute, and it nearly corresponds with the clinical group, acute nephritis, in which the urine is scanty, highly albuminous and frequently bloody, and in which general œdema is a characteristic feature. But acute nephritis frequently subsides into a subacute or chronic stage, and in these, while the parenchymatous changes are still prominent, there are superadded some of the lesions of interstitial nephritis.

In parenchymatous nephritis the secreting structures are specially involved, namely, the glomeruli and tubules, but the degree in which these are respectively affected varies somewhat.

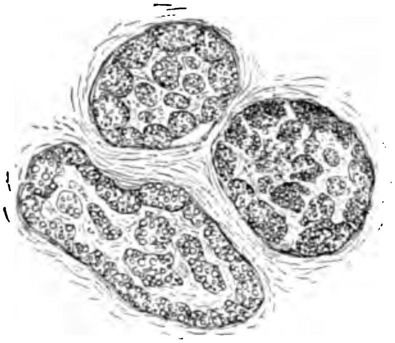

Fig. 642.—Uriniferous tubules with fatty epithelium, some of it shed into the calibre. × 300.

In ordinary cases the **Uriniferous tubules** show very marked changes. These consist in the first place in cloudy swelling of the epithelium with a tendency for the cells to become loosened and shed. The enlargement of the epithelium, occurring mainly in the cortical tubules, causes the latter, under the microscope, to present a strikingly prominent varicose appearance. There are also parts in which the desquamated epithelium distends or chokes the tubules. Fatty degeneration soon affects the epithelium, and it is often present in a very high degree. It does not affect the epithelium uniformly, but at intervals there is a coil of tubules with the epithelium highly fatty (see Fig. 642). The fatty epithelium may be dislodged and packed into further parts of the tube, as into the loops of Henle, so that one often sees a straight tubule occupied by fatty epithelium.

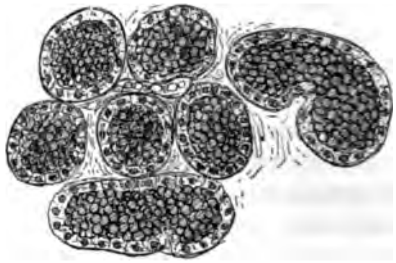

Fig. 643.—A coil of tubules distended with red blood-corpuscles. The epithelium is flattened against the wall. × 300.

Blood is not uncommonly present in the tubules. As the blood escapes from the vessels of the glomeruli it is found in the convoluted tubules. The blood in these tubules is often detectable by the naked eye after removal of the capsule as small red or brown spots on the surface of the kidney. By the aid of a lens these can sometimes be made out as convolutions filled with red matter. Under the microscope fresh blood-corpuscles may be found distending the tubule and flattening its epithelium as in Fig. 643, or the blood may be altered so as to form a brown debris. The altered blood, although chiefly in the convoluted tubules, may extend into the straight ones.

Tube-casts are present in the form usually of translucent hyaline cylinders in the calibre of the tube. They are contained both in the convoluted and straight tubules, and they may be abundant in the pyramids.

As the case becomes more chronic the tubules are liable to considerable distortion, chiefly from the occurrence of interstitial changes. There may be irregular dilatations and contractions of the tubules, but the fatty condition of the epithelium remains prominent.

The **Glomeruli** show various changes. In some cases of scarlet fever there is in the glomerulus and around it a great exudation of leucocytes, which may fill the capsule and crush the tuft so as to conceal it (Fig. 647). The leucocytes also overrun the neighbouring interstitial tissue to a considerable extent, and the conditions may approach to those in septic nephritis. There may indeed be a septic element in many cases of scarlatinal nephritis (see below).

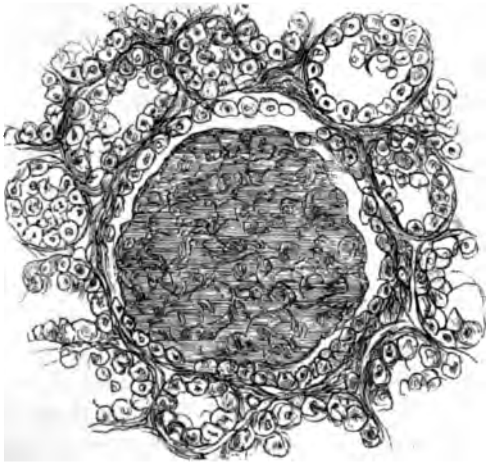

Fig. 644.—Glomerulo-nephritis in scarlet fever. The epithelium lining the capsule is unduly large and abundant. × 350.

The Glomeruli commonly present, in various degrees, changes in their epithelium similar to those in the tubules. There may be merely an enlargement of the epithelium, so that instead of a thin layer which is usually invisible, it may form a distinct row of cells inside the capsule (Fig. 644). In many cases the epithelium multiplies and accumulates inside the capsule (Fig. 645), and the cells sometimes take on a stratified arrangement which has suggested to some authors that connective tissue is formed inside the glomerulus. The epithelium covering the tuft of vessels is affected as well as that lining the capsule.

In addition to this there is very commonly in acute nephritis **Hæmorrhage from the Glomeruli.** The blood which is usually present in the convoluted tubules comes from the glomeruli, and it is often possible, as in Fig. 646, to find glomeruli with blood inside the capsule as well as in the neighbouring tubules.

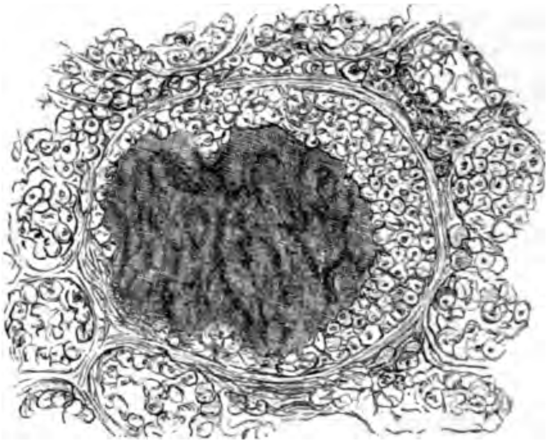

Fig. 645.—Glomerulo-nephritis in scarlet fever. The epithelium lining the capsule is greatly increased so as to crush the tuft. × 350.

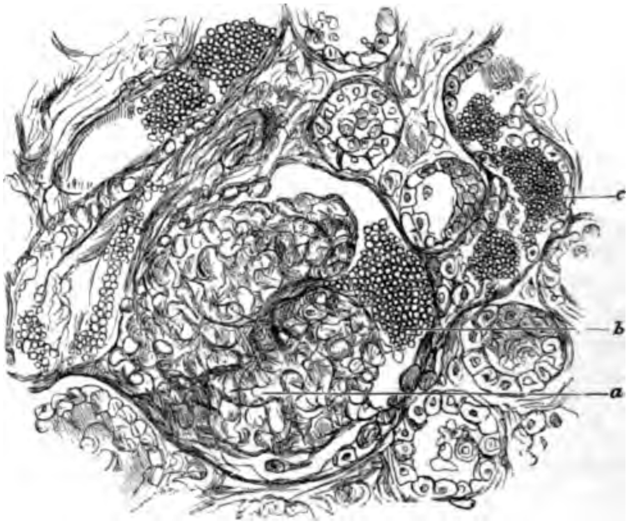

Fig. 646.—Hæmorrhage from a Malpighian tuft in a case of scarlet fever. *a*, tuft; *b*, blood between tuft and capsule; *c*, blood in uriniferous tubule extending from tuft. × 350.

Scarlatinal nephritis, whilst in most cases presenting the usual characters of parenchymatous nephritis, is sometimes characterized by such special changes in the glomeruli that the term **Glomerulo-nephritis** has been employed by Klebs to designate this and other forms in which the glomeruli are specially affected. In some cases of scarlatinal dropsy the kidneys are, to the naked eye, scarcely at all altered, although the patient may have died with symptoms of uræmia. The glomeruli may be visible on section as red spots, and there may be evidences of hæmorrhage, but otherwise nothing abnormal. On microscopic examination, however, there are the marked changes in the glomeruli described above. These lesions must seriously interfere with the function of the tuft. Any accumulation within the capsule will compress the vessels and prevent the transudation of the water and other constituents. There may thus be a suppression of urine from glomerulo-nephritis.

Besides these, which are the results of the specific poison of scarlet fever, there is a form of nephritis which must apparently be referred to the absorption of septic matter from the lesion in the throat. It is not that the microbes themselves are carried to the kidney, but that probably their toxin in the process of excretion leads to what may be called a **Septic nephritis**. The kidney is greatly enlarged and pale. In a case observed by the author, in which the patient died in the ninth day from the onset of the fever, the microscopic appearances were such as are shown in Fig. 647. There was a general infiltration of leucocytes, which occupied the glomeruli and extended to the cortex generally. (See further in papers by Crooke.)

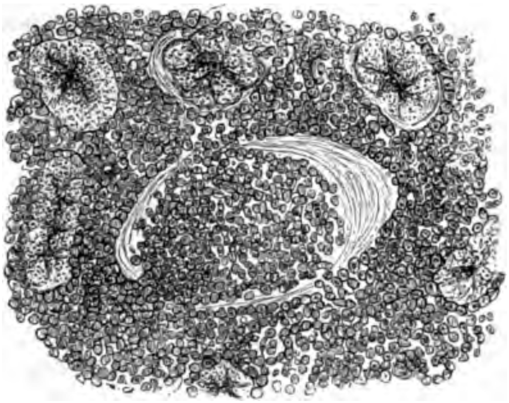

Fig. 647.—Glomerulo-nephritis from a case of scarlet fever. The Malpighian tuft in the middle of the figure is crowded with round cells, which are also present very abundantly in the interstitial substance between the tubules, whose epithelium is granular. × 300.

The interstitial tissue in subacute and chronic cases of parenchymatous nephritis shows marked changes. Even in the acute stage there may be considerable infiltration with leucocytes. As the inflammation is prolonged, however, there is new-formation of connective tissue and that special thickening of the capsule of the glomerulus which is a prominent feature in interstitial nephritis. As this process goes on it produces distortion of the secreting tissue and irregularity of the surface of the kidney.

The naked-eye appearances in parenchymatous nephritis.—If the inflammation be mainly glomerular the general appearance of the kidney may be little altered (see above).

As a general rule in acute nephritis the organ is found enlarged, and it may be more than twice its normal size. The capsule is easily removed, and the surface of the organ has a reddish colour from injection of the vessels. Small red or brown areas are generally visible on close inspection of the surface, these being from hæmorrhages into the tubules. There are also usually opaque yellow patches, from fatty degeneration of the epithelium. On section the cortex is seen to be swollen and thicker than normal, and the hæmorrhage and fatty tubules will be visible as minute red and yellow markings. The latter especially produce a marked mottling of the cut surface in the cortex, and there are often elongated yellow streaks from fat in the straight tubules. The cortex, however, is usually pale as a whole compared with the pyramids.

The **Large white kidney** is a further stage of parenchymatous nephritis. It represents a certain prolongation of the condition with partial subsidence of the inflammation into a subacute stage. The patient has been subject for months or years to intermittent attacks of dropsy with scanty albuminous urine. The kidney is large, and on the surface has a pale appearance, with little or no irregularity. The capsule is non-adherent. On section the cortex is seen to be bulky and pale. On close examination of the surface and of the cortex it is seen that, besides the general paleness, there is an opaque mottling, representing a fatty condition of the epithelium. In the large white kidney the glomeruli and tubules show the changes described above, the glomeruli especially often showing great accumulation of epithelium inside the capsule. In addition there is considerable interstitial new-formation of connective tissue, and, commonly, some sclerosis of the glomeruli.

It is proper to mention that the naked-eye appearances of the large white kidney may be imitated by amyloid disease, where there is also usually some fatty mottling, and by septic nephritis, where there is a general infiltration of leucocytes.

The **contracted fatty kidney** represents the latest stages of parenchymatous nephritis. The organ may be greatly reduced in size, so as to weigh only 2 or 2½ ounces. It is somewhat irregular on the surface, but the appearance is rather of smooth rounded elevations than of granulations. The kidney is soft and flabby in consistence, and the capsule is usually non-adherent. It is generally pale and presents in addition a well-marked fatty mottling in the cortex and on the surface. The shrinking here is chiefly in the cortex, which may be very thin.

The tubules are partly atrophied but partly dilated, and in the latter case their epithelium is usually fatty. The shrinking of the tissue brings the glomeruli close together and they often show marked sclerosis.

(*b*) **Interstitial nephritis** (*Granular contracted kidney, Cirrhosis of the kidney*).—This form of nephritis is for the most part chronic throughout, although sometimes an acute nephritis may pass into it, and it may even ensue on a scarlatinal nephritis. It is chiefly characterized by changes in the interstitial connective tissue, but there are also lesions in the glomeruli, blood-vessels, and tubules. Weigert suggests that the primary changes here may be in the secreting structures, the affection of the interstitial tissue being secondary.

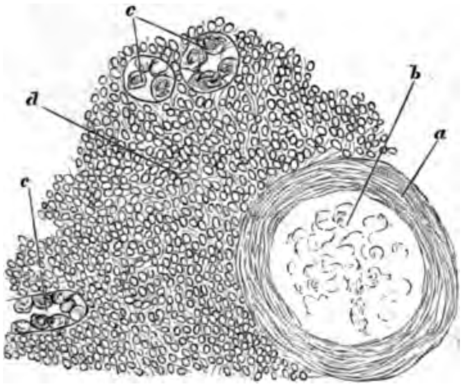

Fig. 648.—Interstitial nephritis. Sclerosis of glomerulus. *a*, thickened capsule; *b*, condensed vessels of tuft; *d*, abundant round cells in interstitial tissue; *c*, dwarfed tubules remaining. × 350.

The interstitial tissue shows, throughout the cortex, a general increase, and it is unduly cellular; but there are also special areas in which the cells are in great excess. These areas are uniformly distributed throughout the kidneys, are usually wedge-shaped with the base at the periphery, and correspond with the regions of convoluted tubules. Whilst there are thus multiple areas in which the inflammation, apparently local from circumstances of structure, is more concentrated, the general connective tissue is increased and shows a coarse fibrous character, markedly different from the normal. The new-formed tissue in the cortex is continuous with the capsule of the kidney and renders it adherent, so that sometimes it is impossible to remove the capsule without tearing the kidney tissue. The connective tissue possesses the contracting character usual in such tissue, and this has an important effect especially on the tubules and capillaries.

The uriniferous tubules in the areas in which contraction has occurred are dwarfed (Fig. 648). In less affected parts, on the other hand, they are frequently dilated, there being here a kind of complementary dilatation. There is thus frequently visible a group of dilated and convoluted tubules (Fig. 649, *b*). The loops of Henle are also dilated, and by the shrinking of the cortex may be doubled up and rendered tortuous (Fig. 649, *c*). The epithelium in the dilated tubules is frequently fatty. **Tube casts** are also present in the tubules, and they may be very abundant. They are usually hyaline in appearance, and are occasionally present in the tubules both of cortex and pyramids.

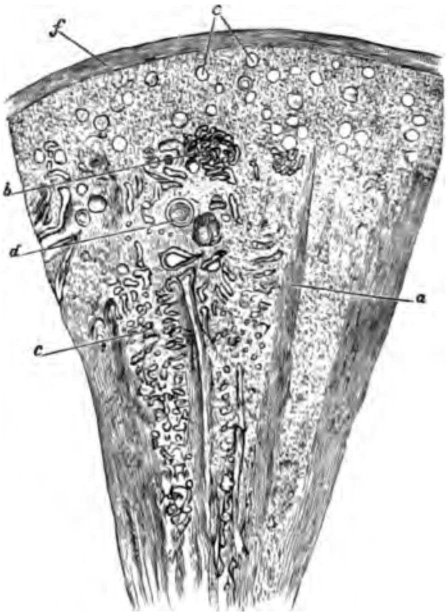

Fig. 649.—Section of contracted kidney with a very low magnifying power. (This should be compared with Fig. 630, p. 1066, similarly magnified.) *a*, medullary rays; *b*, convoluted tubules crushed together and dilated; *c*, region of arteriæ rectæ and loops of Henle, the latter dilated and forming cysts; *d*, large artery between pyramid and cortex, showing endarteritis obliterans; the space between this and surface represents the cortex, and may be compared with similar space in Fig. 630; *e*, glomeruli, closely set and contracted, they also present a white homogeneous appearance; *f*, capsule. × 12.

Cysts are of very frequent occurrence in the contracted kidney. They arise mainly by still further dilatation of the tubules, and very commonly lie together, sometimes in rows, as if from the crushing together and obstruction of a single tubule. Cysts also arise sometimes from the glomeruli, by the accumulation of fluid inside the capsule.

All these cysts result from obstruction of the tubules, and the usual contents are a watery fluid, but sometimes colloid matter is contained in them, apparently arising by secretion from or transformation of the epithelium. In nearly all cases there are cysts visible to the naked eye, and they are frequently so visible in large numbers. But many of them are microscopic in size.

By these processes great dislocation of the kidney tissue results, so that instead of the perfectly regular arrangement of the normal kidney, such as is shown in Fig. 630, p. 1066, there is at once great shrinking and great distortion, as shown in Fig. 649 (drawn by the same apparatus and similarly magnified).

The capillaries are greatly pressed on by the shrinking connective tissue and are greatly obliterated. In this way, in many cases, a very great reduction in the capillaries of the kidney results.

The glomeruli are also strikingly altered. The first change is a thickening of the capsule (Fig. 648, *a*), which shows concentric fibrous layers. The tuft of vessels is subsequently occluded and converted into a dense homogeneous nodule. In this way the glomerulus is greatly contracted, being often reduced to less than half its normal size, and is represented by a solid white glancing nodule in which can still be recognized, as a rule, the thickened capsule presenting its concentric fibrous appearance (*a* in figure), and the central more homogeneous remains of the vessels (*b* in figure). This condition is commonly called **Sclerosis of the glomeruli**, and the resulting appearance is very striking, especially as, with the atrophy of the tubules and contraction of the fibrous tissue, the altered glomeruli are commonly brought close together.

The **Blood-vessels** take part in the inflammation, especially the **Arteries.** Their external coat, being continuous with the interstitial tissue, is thickened along with it. In addition to that, however, the internal coat is usually very markedly thickened. This thickening of the internal coat, which has the characters of **Endarteritis obliterans** (see Fig. 358, p. 555), affects chiefly the ascending and afferent arteries of the cortex, but may also be present in the larger arteries between the cortex and the pyramids. It is sometimes so great as almost to amount to obliteration of the arteries.

It may be questioned to what extent some of the other lesions are due to this narrowing of the arteries. We shall see further on that a primary obstruction of the arteries may lead to atrophy of the tissue and sclerosis of the glomeruli, and, according to Leyden, the lesions in the kidneys produced by lead-poisoning are due to a primary narrowing of the arteries. It may be said, however, in general, that when atrophy is due to a primary endarteritis the affection is localized according to the accidental distribution of the arterial affection, whereas in interstitial nephritis the affection is diffused and homogeneous.

Naked-eye appearances.—The granular contracted kidney is usually small, dense, and tough, and the two kidneys not infrequently show a considerable difference in size. There may be in the early stages some enlargement, and a condition designated large red kidney has been described. The reduction in size varies greatly; in the most extreme cases the kidney weighs about 2 ounces. The kidney feels dense, and on section it is found to be tough. The capsule is firmly adherent, so that on removing it small portions of renal tissue come off with it. The surface has a general red colour, and is almost homogeneously granular. The prominent parts represent the less shrunken portions, and there may be some opaque markings from fat in them.

On the cut surface the regular normal appearance is greatly altered. The cortex is greatly thinned, sometimes forming only a thin rind, scarcely more than a twelfth of an inch in thickness between the bases of the pyramids and the surface. It has lost all its normal markings, and is indefinitely demarcated from the bases of the pyramids. These changes may be partly appreciated by comparing Figs. 630 and 649, where *d* represents in both figures the vessels at the bases of the pyramids, and the cortex is the part between them and the surface. Cysts are also visible on examining the surface.

3. **Character and origin of tube casts.**—It has been pointed out that tube casts are usually present in Bright's disease, whatever the form or stage, and they are known to afford important indications in the urine passed by patients affected by this disease. But they exist in other conditions besides Bright's disease. They are not infrequently present in passive hyperæmia of the kidney, and are also seen in simple atrophic conditions.

They appear as cylindrical casts of the tubules, composed of a clear translucent hyaline material, which, however, may contain in its substance, epithelium, fat, blood, and other matters which are present in the tubules, so that we may have hyaline, epithelial, granular, fatty, or blood casts, all of which may be found in the urine.

The tube casts are for the most part due to exudation from the glomeruli. They usually coincide with the occurrence of albumen in the urine, and they probably arise chiefly by coagulation of the serum-albumen which has transuded into the tubules. They are sometimes called fibrine cylinders, and their discoverer, Henle, regarded them as composed of fibrine. But they do not conform to the characters of fibrine, and as they occur in cases in which there is little or no inflammation they can hardly represent a fibrinous exudation.

Besides this origin they may be derived from the epithelium of the tubules, either by a kind of secretion from the epithelium or by a colloid transformation.

The tube casts which pass into the urine come chiefly from the straight tubules, including the loops of Henle. Those from the convoluted tubules, being thicker and having to pass the narrow loop, are less likely to be carried outwards, although being soft and plastic they may accommodate themselves and so pass outwards.

4. **Functional changes and other phenomena in Bright's disease.**—In this place will be considered the alterations in the functions of the kidney effected by the different forms of Bright's disease, and certain other more general consequences which are liable to follow.

The functional changes in the kidneys are directly expressed by the **condition of the urine,** and these two are properly considered together. In **Acute parenchymatous nephritis** the circulation in the complex vascular system is impeded by the direct effects of the acute inflammation, and also by the pressure of the increased epithelium in the tubules and glomeruli. There is thus a great diminution in the amount of urine. The urine also is highly albuminous, this being an expression of the fact that the special selective function of the glomeruli is paralyzed. The urine usually contains blood. The urea excreted is greatly diminished proportionally to the scantiness of the urine, and the chief danger is the possible occurrence of **Uræmia.**

In **Interstitial nephritis** the alteration in function is very different. Here there is great vascular obstruction and great loss of the secreting epithelium by atrophy, and the result is the secretion of an excessive amount of watery urine which is very deficient in urea. It is easy to understand the diminution of the urea, as in the shrinking kidney there is great atrophy of the epithelium, but the excess of watery urine is more difficult to comprehend in view of the fact that there is great vascular obstruction in which the glomeruli, which are the special seats of the separation of the water, are greatly involved. The dilute condition of the urine is probably to be ascribed to the loss of the tubular epithelium and the occlusion of the capillaries around the tubules. It has been pointed out that the secretion as it leaves the glomeruli is dilute and that it is concentrated in its passage through the convoluted tubules. This concentration is hindered by atrophy of the epithelium and capillaries, so that the urine as secreted may be regarded as virtually the secretion **as it leaves the glomeruli.**

Intimately related to the condition of the urine are the increased arterial tension, and organic changes in the heart and arteries, which are so characteristic of chronic Bright's disease.

Increased arterial tension or increase in the entire arterial blood-pressure is an early phenomenon in interstitial nephritis; some have even believed it to precede the kidney disease. In order to induce a general increase in the arterial blood-pressure there is necessary either an increase in the peripheral resistance, such as may be produced by a general contraction of the arterioles, or an increase in force of the left ventricle. In interstitial nephritis we have both of these.

Hypertrophy of the left ventricle is one of the regular phenomena of chronic Bright's disease, so that the existence of the latter may often be suggested by that of the former. The heart has the elongated form described and figured at p. 506, Fig. 310.

Thickening of the walls of the arteries generally is the other phenomenon. This has been variously described as a thickening of the external coat mainly, an **Arterio-capillary fibrosis**, or a thickening of the middle coat, but it really consists for the most part of a general thickening, as shown in Fig. 650, involving both coats. It is detectable most readily in the arteries of the pia mater, which are easily examined by spreading out a small part of this fine membrane. Besides these thickenings, we have frequently atheroma in Bright's disease in people advanced in life.

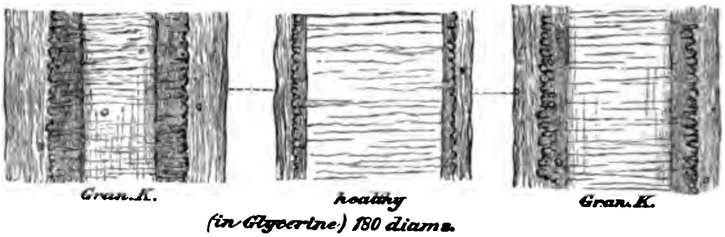

Fig. 650.—Arteries of the pia mater in case of granular kidney and in health. In the former the middle coat and, to some extent, the external are thickened. (Dickinson.)

These thickenings of the arteries, whilst contributing to the increase in blood-pressure, are also in part its results. The blood entering the arteries with increased force requires greater resistance in the walls of the arteries in order to prevent dilatation, and may require also an energetic contraction to prevent an excess of blood from passing through the arteries. The arteries subjected to increased blood-pressure are probably more liable to secondary changes such as atheroma.

The increase in blood-pressure involving such considerable structural changes seems such a large result from a local disease of the kidneys that several authors (especially Gull and Sutton) have come to the conclusion that chronic Bright's disease is a general affection of the fine arteries throughout the body, and that the kidney lesion is merely a part of this more general condition. This view is expressed in the term Arterio-capillary fibrosis introduced by Gull and Sutton. As a main element in determining whether the conditions under consideration are consequences of the kidney disease, the question may be asked whether increase of blood-pressure with hypertrophy of the left ventricle occurs in cases of disease of the kidney undoubtedly local in its character. The answer to this question is that diseases of the kidney which induce obstruction to the vessels similar to that in chronic interstitial nephritis do lead to the conditions under consideration. Thus, hydronephrosis with atrophy of the kidney tissue has repeatedly been observed to lead to it. Dickinson records a case in which a stone in the pelvis of the kidney produced contraction of the kidney and led to hypertrophy of the left ventricle. It may result from partial atrophy of the kidney from arterio-sclerosis, as in two cases observed by the author. Again, it has been produced in animals by inducing in them an indurative nephritis, which was done by ligaturing the renal artery for an hour and a half to two hours and then freeing the vessel.

It is obvious from these observations that the hypertrophy of the heart is related in its causation to the lesions in the kidney, and it may be said generally that, whenever there is considerable vascular obstruction in the kidneys, hypertrophy of the heart is liable to occur, unless the health of the patient be too low to allow of such a formative process. It is not usually marked in amyloid disease of the kidney, as the amyloid condition frequently depends on lesions which seriously injure the health, and it is not nearly so common in parenchymatous as in interstitial nephritis, for the double reason that the vascular disturbance is much less, and the interference with the general health greater in the former than in the latter.

The changes in the arteries throughout the body consist in thickenings of their coats.

The explanation of the increased blood-pressure is still to be considered, and this is somewhat obscure. It is due to the condition of the kidneys, but the mere vascular changes there are not sufficient to account for it. Increase of the general blood-pressure is caused by arterial and capillary obstruction such as exist in the kidneys in this disease; but, considering the means at the disposal of the vascular system for compensatory dilatation of arteries, such a local obstruction is insufficient to account for a general rise in pressure.

The changes seem inexplicable on a purely mechanical theory, and the explanations of Cohnheim as amplified by Fagge seem the most probable. In all the cases in which the cardiac and vascular changes occur there is obstruction to the vessels in the kidney, chiefly the arteries and the capillaries of the tufts. In order that the proper amount of urine may be secreted the blood must circulate much more quickly through the remaining vessels. This can only be effected by a rise in the blood-pressure in the vessels concerned which may be brought about by a relaxation of the larger renal arteries. The activity of the renal secretion seems to be largely determined by the amount of urea and other constituents in the blood, the condition of the arteries as to contraction being regulated through the nervous system (Cohnheim and Roy). But if the local dilatation of the arteries be inadequate to cause a sufficient flow of blood, and the urinary constituents still tend to accumulate, then there can only be a relief by a general rise in the blood-pressure brought about by increase in the force of the cardiac contractions. In this view of it the cardiac hypertrophy is compensatory, and is brought about in order to prevent the undue accumulation of urea in the system.

Œdema and Dropsy.—Anasarca or œdema of the skin is an early and characteristic symptom of acute parenchymatous nephritis. The subject has been already considered at pp. 103, 104. The œdema of the skin appears to be related, on the one hand, to the excess of water retained in the blood, and, on the other, to the irritation of the skin by the abnormal constitution of the blood. The irritant which acts on the kidneys will also act on the skin.

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VI.—EMBOLIC INFLAMMATION. METASTATIC ABSCESSES.

In **Pyæmia and Ulcerative endocarditis** pieces of fibrine or other material may be carried to the kidneys and produce embolism there.

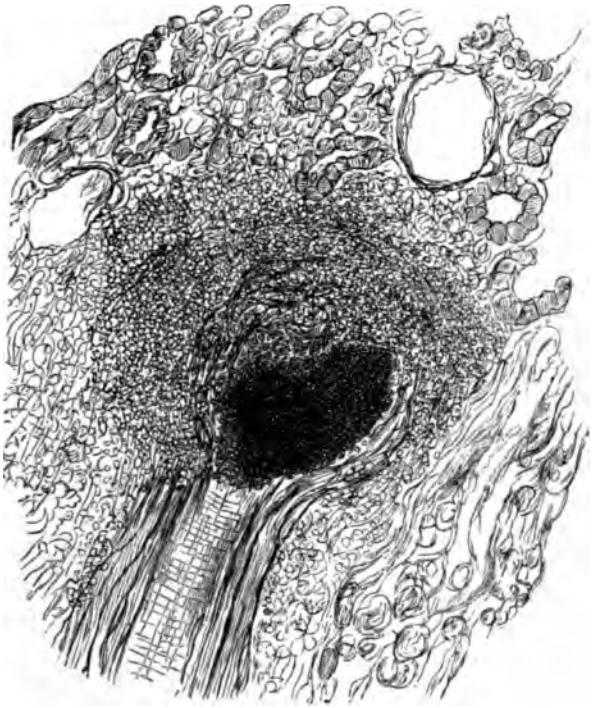


Fig. 651.—From a section of the kidney in ulcerative endocarditis. An artery is plugged with dark material which contains micrococci. In the neighbourhood of the plug the wall of the artery is necrosed. Leucocytes are infiltrating the tissue around and extending through the vessel wall. × 90.

In this way arise **Metastatic abscesses.** For the most part the emboli are small and are carried to the ascending arteries or the glomeruli before they are caught. Hence the abscesses are mostly in the cortical substance, although they are not infrequently seen in the pyramids along the course of the arteriæ rectæ, and there may even be large ones taking in portions both of the pyramids and cortex. The abscesses are usually elongated in the direction of the arteries, and they often project slightly from the surface when the capsule is removed. They are frequently present in considerable numbers in both kidneys.

Under the microscope the abscesses are seen to arise from obstruction of the arteries (see Fig. 651). Where the embolism has been recent the wall of the vessel and the tissue in the immediate neighbourhood of the embolus present evidences of necrosis, while around there are multitudes of leucocytes occupying the interstitial tissue. In the embolus there are colonies of microbes in the midst of remains of the transported fibrine. When the abscess has fully formed, these characters may be lost in the great multiplication of leucocytes. Besides in the arteries colonies of microbes are to be found in the vessels of the glomeruli, sometimes filling many of them with a dark granular mass, and also in the capillaries. It may sometimes be seen that these colonies are present in the glomeruli and capillaries without any sign of inflammation around. In such cases they are of recent growth and have not had time to produce inflammation by giving off irritating products. To some extent the bacteria may multiply in the glomeruli and capillaries after death.

In scarlet fever there is rarely a true suppurative nephritis, but in some cases the kidneys are greatly enlarged and infiltrated with leucocytes. These cases are probably due to the presence of septic products, absorbed from the lesion in the fauces. Microbes are not infrequently found in the capillaries of the kidney in scarlet fever (Fig. 652) and diphtheria, and they may also pass into the tubules.

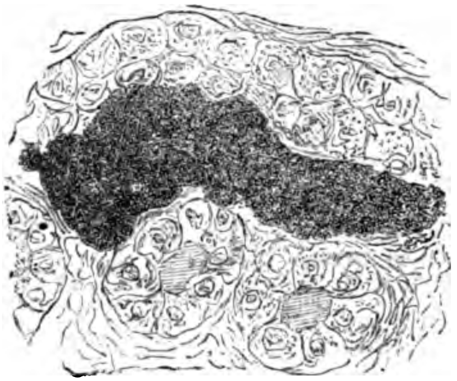


Fig. 652.—Bacteria distending a capillary blood-vessel in a case of scarlet fever. × 350.

VII.—INFLAMMATIONS OF THE PELVIS (PYELITIS, PYONEPHROSIS) AND OF THE KIDNEY IN ASSOCIATION WITH THE PELVIS (PYELONEPHRITIS).

The various terms mentioned in the heading refer to inflammations which generally arise by extension from the bladder up the ureter to the pelvis and kidney. Pyelitis is an inflammation of the pelvis of the kidney, pyelonephritis is a suppurative inflammation involving the pelvis and the substance of the kidney. Pyonephrosis is a suppuration in a distended pelvis.

1. **Pyelitis.**—Inflammation of the pelvis of the kidney is not always suppurative, as it may be produced by other causes besides septic agents. A catarrhal pyelitis occurs in the course of some fevers, or it may be present to some extent in acute Bright's disease.

Calculi, by their mechanical irritation, induce inflammation of the pelvis, often spoken of as **Calculous pyelitis** (see Fig. 653). It is sometimes said that calculi produce suppurative inflammations, but this can scarcely occur unless there be an extension of the septic process from the bladder upwards. The irritation, however, may lead to such inflammation as to cause a considerable abundance of leucocytes in the urine. On the other hand, septic inflammations, being accompanied by decomposition of the urine, often result in the formation of calculi.

The presence of calculi in the pelvis of the kidney has frequently an irritative effect on the kidney itself. Thus there arises in some cases a regular interstitial nephritis, the condition of the kidney coinciding with that in chronic Bright's disease. As already mentioned the contracted kidney so produced may give rise to hypertrophy of the left ventricle and the other associated phenomena.

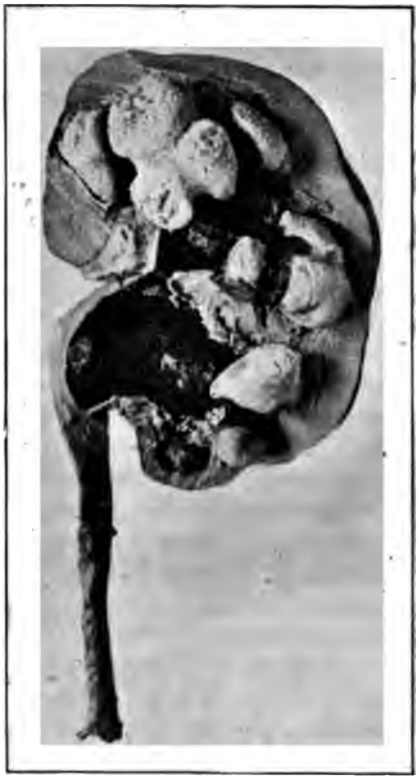


Fig. 653.—Calculous pyelitis. The calices are filled with branched calculi and the pelvis is obstructed.

Suppurative pyelitis is the result of the extension of septic processes from the bladder by the ureter. It usually occurs in cases where there is some obstruction at the neck of the bladder or in the urethra, and where a cystitis with decomposition of the urine has occurred.

There is frequently some coincident dilatation of the pelvis, and there may be a proper pyonephrosis.

The mucous membrane is thickened and frequently of a bluish colour. It is not infrequently incrusted with phosphates. The contained matter is a thick brownish ill-smelling pus.

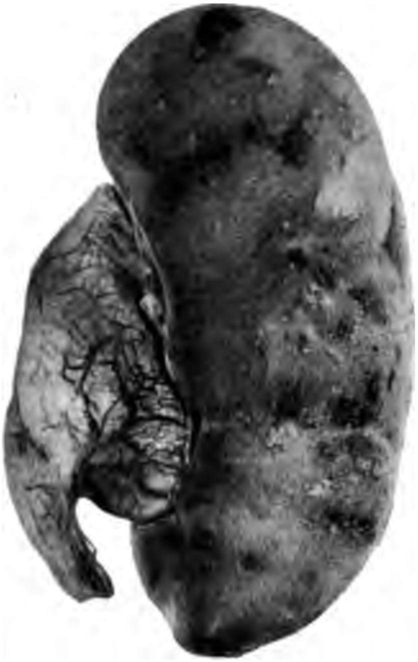


Fig. 654.—Suppurative nephritis. Numerous small abscesses are seen on the surface of the cortex. The pelvis is dilated and contained pus.

2. **Pyelonephritis, Suppurative nephritis.**—By the term pyelonephritis is meant a combined inflammation of pelvis and kidney. As this inflammation is mostly septic the usual result is a suppurative nephritis. The disease mostly connects itself with that just described as suppurative inflammation of the pelvis and leads to a suppurative inflammation of the kidney (see Fig. 654).

There are two modes in which the condition may be brought about. On the one hand the irritating products from the pelvis may be carried into the kidney, being absorbed either by the tubules or the lymphatics, or on the other hand the microbes may themselves extend into the kidney. This latter method is much the more frequent. Colonies of micrococci have been observed in the uriniferous tubules as well as in the lymphatics.

The lymphatics of the kidneys, according to Steven and Newman, are in communication with those of the ureter. When an injection is thrown with some force into the ureter, it passes into the adventitia of this canal, and thence to the capsule of the kidney. The lymphatics of the capsule communicate with those of the kidney, so that stellate vessels are visible, in these injections, on the surface of the kidney, and are found to penetrate deeply into the cortex.

Pyelonephritis mostly manifests itself in the form of multiple abscesses in the kidneys, the extension being by the second method mentioned above. That is to say, micrococci extend into the kidney in an irregular fashion and each colony of microbes becomes the focus of an abscess. The abscesses exist both in the pyramids and cortex. They may be scattered over the kidney so that the appearance may resemble pyæmia, but they are frequently in groups, certain areas containing a number of purulent centres (Fig. 654). They are small in size, but by coalescence may reach larger dimensions. The groups are frequently more or less wedge-shaped, the base at the cortex and the apex far down in the pyramid or even at its apex.

When the propagation is by the lymphatics the abscesses will be chiefly on the surface of the kidney, partly involving the capsule. It is not uncommon to open abscesses in the process of stripping the capsule. It sometimes happens that abscesses form by this mode of extension without the pelvis being affected, the extension occurring by the wall of the ureter to the surface of the kidney, but generally both modes of extension co-exist, and there are abscesses in the substance as well as at the surface of the organ.

A more rare circumstance is that the entire organ is infiltrated, especially in the cortex, with leucocytes, and the appearances presented are those of an acute interstitial nephritis, such as that above mentioned as sometimes resulting from scarlet fever. This may perhaps be the case when the irritant is diffused from the pelvis in solution.

When the abscess-formation is one-sided, **healing** may take place. The kidney is then the seat of numerous cicatrices, a condition which Moxon has named the **Cicatricial kidney.**

Literature.—Beck, Reynolds' Syst. of Med., v., 1879; Dickinson, loc. cit.; Newman, loc. cit.; Steven, Glas. Med. Jour., xxii., 1884; Moxon, Path. Trans., xxiii., 1882; Jores, loc. cit., 1901; Morris, Surg. Diseases of the Kidney, 1902.

3. **Pyonephrosis.**—This term is used when, along with or following a hydronephrosis, suppuration occurs in the dilated structures. This is usually the result of an extension upwards from the bladder, such as has just been referred to. It may be followed by suppurative inflammation of the kidney, and in that case is usually fatal (see Fig. 655).

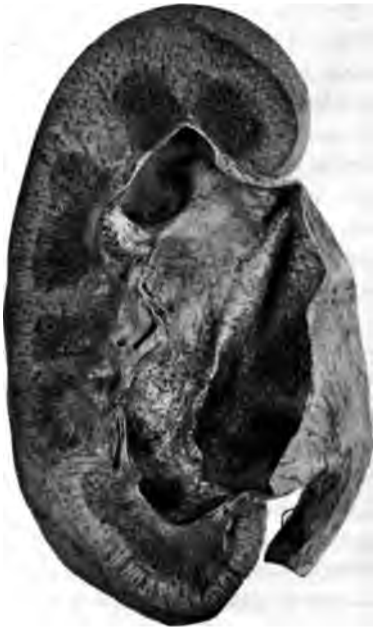


Fig. 655.—Pyonephrosis with suppurative nephritis.

Such extension upwards will usually occur in cases where the primary condition, which probably corresponds to the seat of obstruction, is in the bladder or urethra, hence it may be bi-lateral, and in that case is almost certainly fatal. However, it is not uncommonly uni-lateral, the extension having only occurred up one ureter. In that case there may be an abscess-like cavity formed, the dilated pelvis and calices being filled with pus.

If the affection of the lower urinary tract is recovered from, healing may take place in the kidney. One of the most constant results in this case is obliteration of the pelvis or upper part of the ureter, so that the kidney is shut off from the latter. By the obliteration of the pelvis the kidney is converted into a series of cysts, each independent of the other, and representing dilated calices (see Fig. 656). In these cysts pus is at first present; but as the corpuscles die and the fluid is absorbed, the pus dries in and leaves a pultaceous matter in which lime salts are abundantly present (*a* in figure). It is not uncommon to meet with a kidney thus converted into cysts filled with putty-like matter, and it is remarkable that along with these there may be some cysts in which clear serous fluid is present. Compensatory hypertrophy of the other kidney may complete the cure.

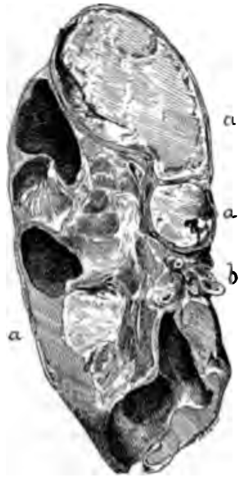


Fig. 656. — Healed pyonephrosis. *b*, obliterated pelvis; *a*, *a*, *a*, cavities filled with pultaceous matter. There were other cavities which contained serous fluid.

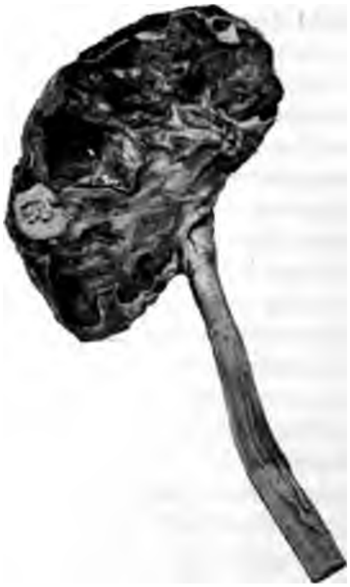


Fig. 657.—Healed tuberculosis of the right kidney. There was marked compensatory hypertrophy of the left kidney.

The above was believed by the author to be the course of events in cases of the kind referred to. The description was based chiefly on cases which had come under his own observation. In one such case there was obstruction in the urethra in a female, with hypertrophy of the bladder. One kidney was found in the healed condition described above, while the other showed compensatory hypertrophy. This patient died from bronchitis without, latterly, any renal symptoms. In another case one kidney showed pultaceous masses, while the other presented a recent suppurative inflammation which had proved fatal. There was a prolonged affection of the bladder, with, apparently, an extension first to one kidney, producing a pyonephrosis partly recovered from, and then to the other, leading to a fatal result. It is not to be denied, however, that somewhat similar appearances may result from healing of a tuberculosis of the kidney (see Fig. 657). In this case, however, there will be signs of tuberculosis in the ureters, and probably in other parts of the genito-urinary tract.

VIII.—RETROGRADE CHANGES IN THE KIDNEYS.

Retrograde changes are of frequent occurrence in the various forms of Bright's disease, but they may also occur independently.

1. **Amyloid degeneration of the kidneys.**—Amyloid disease is of more importance in the kidneys than in other organs, both because in itself it leads to albuminuria and because its presence probably induces further structural changes in the organ. These facts induce some authors to include it as a form of Bright's disease. It exists along with amyloid disease of other organs, and is secondary to some diseases which affect the body generally, chiefly phthisis pulmonalis and syphilis. In syphilis it not infrequently assumes more of an independent character, and the case, as a whole, may assume the aspect of one of kidney disease.

The view expressed by the author at p. 399 that amyloid disease is produced by the direct action of the morbid poisons concerned in the diseases which lead to it, rather than by the drain on the system which these diseases sometimes cause, is confirmed by the experimental observations of Krawkow. He induced amyloid disease in a number of animals of different kinds by the subcutaneous injection of cultures of staphylococcus pyogenes aureus, but did not succeed in producing the condition when suppurations were produced by other kinds of agents such as turpentine. He expresses the opinion that the products evolved by the microbes constitute the essential cause. He produced amyloid disease in one case by injecting a filtrate of the bacillus pyocyaneus. (See Krawkow, Centralbl. f. allg. Path. u. path. Anat., May, 1895.)

The lesion in the kidneys as in other organs affects primarily the walls of the blood-vessels (Fig. 658). Even in very early cases, in which the amount of amyloid disease is slight, we usually find it in two distinct and separate structures, namely the Malpighian tufts and the arteriæ rectæ of the pyramids. The **Vessels of the glomeruli**, generally along with the arteries leading to them, are swollen and hyaline. The rose colour developed with methylviolet is so striking that in sections stained with this dye it often looks as if the tufts were injected. They are also considerably enlarged, and even without the addition of iodine or methylviolet they form very prominent, transparent, and glancing clumps in the cortex. The **Arteriæ rectæ** run, as we have seen, in bunches, and their appearance with methylviolet is that of a series of rose-coloured tubes grouped together. They are also sufficiently pronounced as a rule to be seen without any reagent, appearing as pearly glancing tubes.

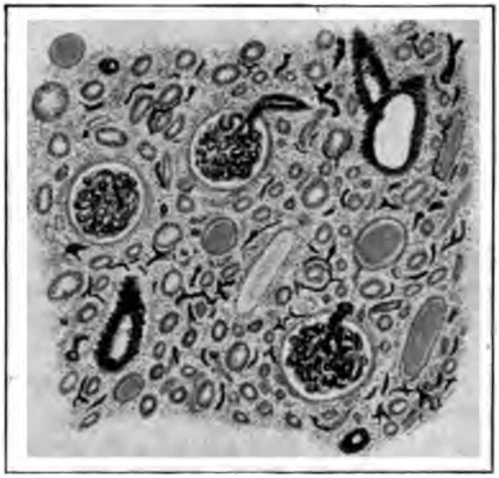


Fig. 658.—Waxy degeneration of the kidney. × 50.

While these structures are first and chiefly involved, others usually follow. There is amyloid disease extensively present in the **Arteries of the cortex**, the ascending and afferent arteries. In these the lesion can often be seen to begin in the muscular coat, a distinct transverse marking being visible either from the muscular fibre cells being mapped out by the staining agent, or by structures lying between the muscle cells being affected. Very often there is here and there a **capillary** of the cortex affected, and sometimes these are extensively so, even in comparatively slight cases. The **Basement membrane** of the tubules (see Fig. 659) frequently becomes amyloid in advanced cases, chiefly of those of the cortical substance.

Along with the amyloid disease of the vessels there is usually **Fatty degeneration** of the epithelium of the tubules, apparently the result of anæmia from the obstruction of the vessels.

Interstitial inflammation nearly always accompanies amyloid disease. It is usually slight in degree, but it may be so great as to produce a combination of chronic interstitial nephritis and amyloid disease, as in Fig. 660, where the glomeruli are brought close together by atrophy of the tubules from interstitial inflammation, and the organ as a whole is contracted.

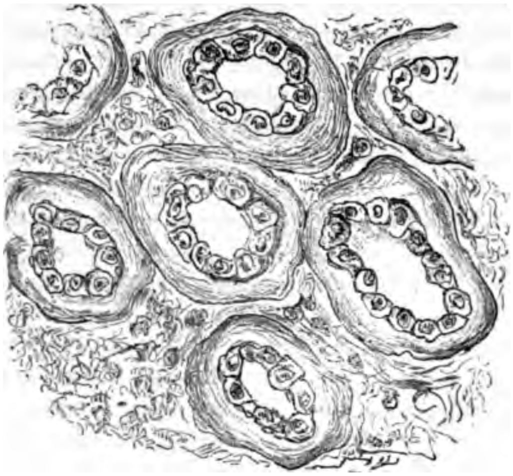


Fig. 659.—Amyloid degeneration of the basement membrane of the uriniferous tubules. The thickened and translucent basement membrane is shown with the renal epithelium inside. × 350.

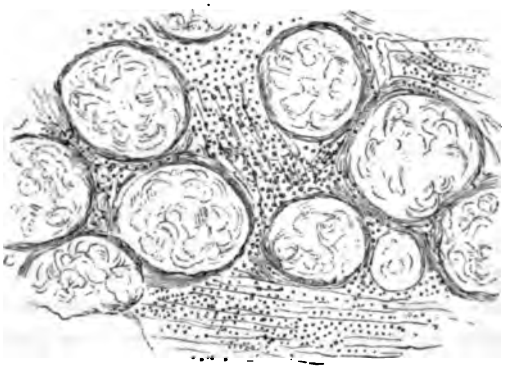


Fig. 660.—Amyloid and contracted kidney. The highly amyloid and therefore greatly enlarged Malpighian tufts are shown; their capsules are somewhat thickened. The tufts are unduly close together, owing to contraction of the intervening tissue. Between them there is round-cell tissue with remains of tubules. × 85.

The mere existence of amyloid disease probably gives rise to interstitial inflammation, but it is not improbable that the primary disease which led to the amyloid condition may also induce nephritis. Thus in syphilis the virus affecting the kidney directly may cause interstitial inflammation, while less directly it produces a general amyloid condition. Again, in phthisis pulmonalis, and in extensive suppurations from diseased bone, there may readily occur an absorption of irritating materials which in process of excretion by the kidneys are capable of setting up inflammation.

The contracted amyloid kidney is not generally accompanied by hypertrophy of the heart, the reason apparently being that, as the blood is impoverished, the compensatory growth of muscular tissue can scarcely occur.

In regard to the **Naked-eye appearances**, the simple amyloid kidney is enlarged, sometimes greatly enlarged, so that the organ weighs nine or ten ounces. The surface is pale and the capsule comes off easily. On section the cortex is seen to be thickened and pale in colour. The general appearance therefore resembles that of the large white kidney, and doubtless many cases have been mistaken for that. But the organ in amyloid disease has a firm elastic feeling and a translucent appearance on section, which is distinctive enough. The thick pale translucent cortex usually contrasts with the redder pyramidal substance, and the appearance has been somewhat aptly compared to the section of bacon. The name **Lardaceous kidney** is often applied from the translucent appearance of the tissue. In the midst of the transparent basis opaque yellow streaks are often visible, due to fatty degeneration of the epithelium. The addition of a solution of iodine to the cut surface of such a kidney brings out the affected glomeruli as brown dots and the arteriæ rectæ as brown streaks. If the kidney be contracted, the granulations on the surface show the usual transparent waxy appearance of the amyloid kidney, and on section the cortex, though greatly thinned, shows a similar condition.

The structures affected with amyloid disease apparently allow fluid to pass through them more readily than normal structures. Injection of the amyloid kidney shows that the vessels of the glomeruli and the arteries of the cortex are largely obstructed. It may well be that this leads to increased blood-pressure in the remaining arteries, but with the general narrowing of the smaller arteries this can hardly tell with much force on the glomeruli which remain pervious. This excessive secretion of urine, like the diarrhœa which is a prominent symptom in amyloid disease of the intestine, is probably to be accounted for by a greatly increased permeability of the vessels.

2. **Atrophy.**—A local atrophy sometimes occurs from **Endarteritis** (see Fig. 661). There are flat depressions on the surface which may give the kidney a somewhat coarsely granular appearance, but sometimes these are extensive, involving considerable areas of the kidney.

In this latter case the larger arteries running between cortex and pyramids are affected with endarteritis, which may be an **Atheroma** associated with a similar condition in other arteries. The thickening of the internal coat is extreme (see below *e* in Fig. 661), and in the smaller branches amounts to absolute occlusion.

The atrophy has considerable resemblance in its details to that in chronic interstitial nephritis, but also presents considerable differences. It is not limited to the cortex, but involves the pyramids as well, and there is much less distortion but more of a simple diminution or disappearance of the tubules. The affected areas are very strikingly reduced in volume, so that the hilum of the kidney comes close to the surface (see between *a* and *e* in figure). This contrasts greatly with the neighbouring unaffected parts in which the cortex is even more voluminous than normal.

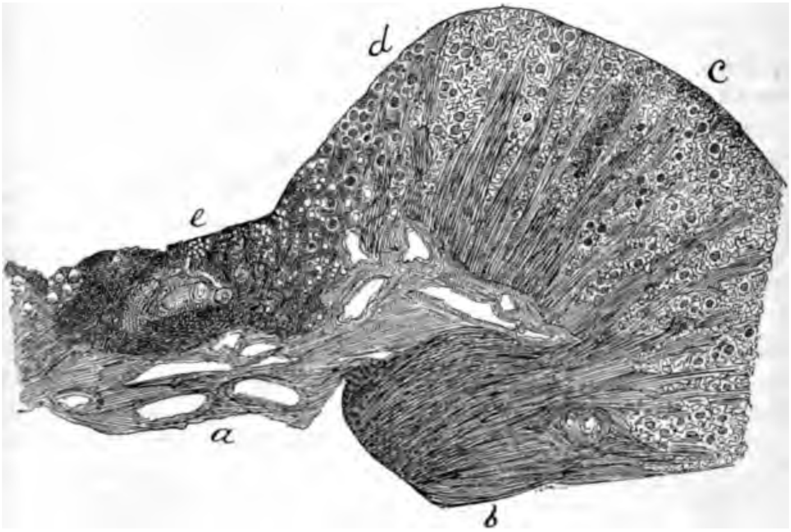


Fig. 661.—Local atrophy from endarteritis. *a*, hilum of kidney; *b*, normal pyramid; *c*, normal cortex showing glomeruli, medullary rays, etc.; *d*, atrophy beginning, the convoluted tubules atrophied while glomeruli remain. On approaching *e* the glomeruli become greatly contracted and are drawn close together. × 6.

By the **Atrophy of the tubules** the glomeruli are brought close together, so close in many cases as to show that the tubules have virtually disappeared. In the pyramidal portion the atrophy of the tubules causes the intertubular substance to become very prominent as a clear translucent matrix interrupted by small round areas. **The Glomeruli** are themselves in a state of sclerosis. At the marginal parts of the affected areas this condition is seen to begin by a thickening of the capsule, which is less fibrous than in the sclerosis of interstitial nephritis, but has rather a hyaline appearance. The occlusion of the vessels in the tuft and the solidification of the glomerulus follow. In many parts the remaining tissue consists of little more than closely aggregated and solidified glomeruli, these being, apparently, in their altered state, very persistent.

In addition to these evidences of atrophy there is some infiltration of round cells, but not any considerable new-formation of fibrous tissue.

The description given above of local atrophy from endarteritis is based on the observation of two well-marked cases in which nearly half the kidney tissue was atrophied, the locality of the atrophy being chiefly in the neighbourhood of the hilum, and generally continuous, although also with isolated patches. An interesting feature in both these cases was the co-existence of hypertrophy of the left ventricle. The importance of the fact that local atrophy of the kidneys may have such a result has already been referred to.

In **Senile atrophy** the whole structures of the kidneys undergo diminution in size, but very often this affects especially the secreting epithelium of the convoluted tubules. If this be the case there may be a special shrinking of the cortex, and the kidneys may be like those of chronic Bright's disease. Sometimes also the surface is granular and the capsule adherent.

3. **Parenchymatous infiltration**, or **Cloudy swelling**. Besides forming one of the lesions in acute Bright's disease, this is liable to occur in acute febrile diseases. There is a general enlargement of the renal epithelium with infiltration of fine granules in the midst of which minute fat drops are scattered (Fig. 212, p. 384). The pyramidal tubules as well as those of the cortex are involved, the affection being usually homogeneously distributed. It is important to note that this condition may produce considerable enlargement of the kidney without obvious change in its structure to the naked eye.

4. **Fatty degeneration** of the renal epithelium is not infrequently present in cachectic conditions, such as advanced phthisis pulmonalis, in which, however, it is often associated with amyloid disease or interstitial nephritis. In severe anæmias it is met with along with fatty degeneration of the muscular substance of the heart. It occurs also in acute yellow atrophy of the liver.

IX.—CONCRETIONS AND CALCULI IN THE KIDNEY.

Two very interesting forms of **Deposition in the tubules** are met with **in new-born children.** In the common icterus of the new-born the **Biliary colouring matter** (bilirubin) is excreted, as in the adult, by the kidneys, but in the new-born it very readily passes into the

Crystalline form, so that round masses or rhombic orange-coloured crystals are found in the pyramidal tubules, sometimes in such numbers as to warrant the designation bilirubin-infarction. Similar crystals are found in the blood and tissues of the body.

In adults, icterus is also accompanied by deposition of pigment in the tubules, but it is in the form of brown or yellowish masses.

Uric acid salts are found in the tubules of new-born children, in about half the cases of those who die within the first few weeks. It is mostly in children who have breathed that they are met with, but they have been observed in still-born children, although rarely. The concretions consist mostly of urate of ammonia. They are deposited mainly in the tubules near the apices of the pyramids, giving the appearance of opaque yellow or reddish streaks, converging to the apex of the pyramid. Under the microscope amorphous urates are seen in the tubules, and when acetic acid is applied these dissolve and form crystals of uric acid.

Urates are also deposited in the substance of the kidney **in Gout.** They are visible to the naked eye in the pyramidal portions of the kidney, especially towards the apices, as white streaks. With the microscope they are seen to occupy the tubules, which are dilated. There is usually a co-existing **interstitial nephritis.**

Lime salts are sometimes deposited in the tubules of the kidney. This can be experimentally produced in rabbits by the administration of mercuric chloride and a few other poisons. It has also been seen in cases where from disease of bone there is excessive absorption of lime salts and excretion of them by the urine. The appearance presented in this case is that of white streaks usually near the apices of the pyramids. It is to be observed, however, that a deposition of urates occurring in the straight tubules after death may produce a somewhat similar appearance.

Calculi in the pelvis of the kidney are of frequent occurrence. As we have seen, they may originate in chronic pyelitis, especially with stagnation of urine, and they may also arise in the uriniferous tubules, and having passed into the pelvis grow larger there. The calculi may be composed of uric acid, of phosphates, of oxalate of lime, or of cystine. The character of each of these is described in the section on Calculi in the Bladder.

The calculi sometimes attain very large dimensions, moulding themselves into the shape of the pelvis and calices, so that we may have branches extending out into elongated recesses formed by dilated calices (Fig. 662). By obstructing the flow of urine these calculi may lead to the occurrence of hydronephrosis, and as the cavity of the pelvis and calices enlarges so may the calculus. A small calculus often passes into the ureter and obstructs it, in this way leading to hydronephrosis.

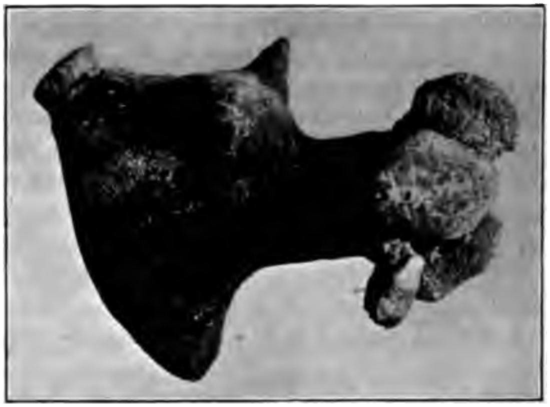


Fig. 662.—Renal calculus. Actual size.

X.—SYPHILIS AND TUBERCULOSIS OF KIDNEY.

1. **Syphilis** is sometimes the cause of diffuse **Interstitial nephritis.** It is undoubtedly a frequent cause of **Amyloid disease,** and may by this means lead on to chronic nephritis. It is probable that many cases of contracted amyloid kidney have this origin. Hereditary syphilis is also believed to give rise to a diffuse interstitial nephritis.

Gummata are rare in the kidney. They are found in the midst of cicatrices as in the case of the liver.

2. **Local tuberculosis or Renal phthisis.**—This condition is usually associated with tuberculosis elsewhere. Thus there is commonly tuberculosis of the ureter and bladder, and also, in the male, of the vesiculæ seminales, vas deferens, and testicle. It seems probable that in most cases the tuberculosis originates in the testicle and travels to the other parts (Weigert), but an origin in the kidney itself is not to be excluded. Nevertheless the fact that the disease is rare in females would indicate that the propagation is usually from the testicle. Renal phthisis is frequently associated with pulmonary phthisis, which is probably in most cases the primary affection.

The disease is usually very advanced in one kidney and absent or slight in the other. In the advanced cases the kidney is converted internally into a sac with irregularly ulcerated walls, and divided partly into compartments by the remains of septa. The ulcerated surface presents some adhering caseous matter and the wall is infiltrated, the whole pelvis presenting the appearances shown in the lower part in Fig. 663. The capsule of the kidney is adherent. Hamill describes what he believes to be a case of tuberculosis of the kidney with complete destruction in a child of seven months, and gives summaries of recorded cases of this kind. He does not describe typical tubercles and did not find the tubercle bacillus.

In an early stage we find, it may be, the apex of a pyramid the seat of a small ulcer with yellow caseous walls, and with grey tubercles at the periphery in the substance of the pyramid. The lesion begins usually in the calices, frequently in those situated inferiorly, as in Fig. 663, and eats its way in, attacking and destroying the kidney tissue in its advance. There is a very irregular extension of the ulceration, but usually there is some indication of the calices preserved.

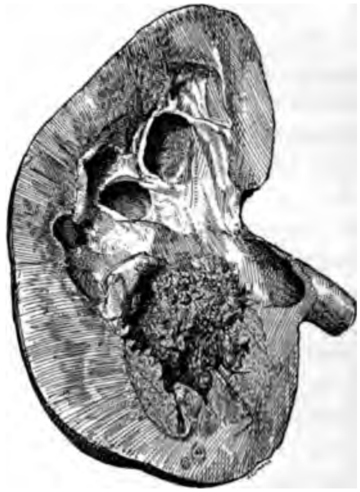


Fig. 663.—Tuberculosis of kidney with hydronephrosis. At lower part a ragged tubercular ulcer eating into kidney tissue. Two small isolated tubercular areas below. In upper part dilated calices (hydronephrosis). To right dilated ureter.

The **Pelvis and Ureter** partake in the tuberculosis, and the latter is often infiltrated either in patches or throughout. Its wall is greatly thickened, and its internal surface often presents an almost continuous layer of caseous matter.

There is sometimes a partial **Hydronephrosis** (as in figure) along with the tuberculosis, from the caseous matter obstructing the ureter. It also happens sometimes that tuberculosis in one kidney is associated with hydronephrosis in the other. In such cases the tuberculosis of the bladder, affecting the orifice of the ureter, has caused obstruction of it and hydronephrosis has ensued.

The tuberculosis sometimes attacks a pervious branch of **the Renal artery**, and the tubercular virus is disseminated over the area of distribution of the artery. Hence it is not uncommon to find a larger or smaller wedge-shaped piece of kidney occupied by closely aggregated tubercles, while there is a comparatively slight tuberculosis of the pelvic portions. A general tuberculosis may develop from this.

Healing occasionally occurs in tuberculosis of the kidney (see Fig. 657).

3. **General tuberculosis.**—A **Chronic general tuberculosis** is not uncommon in children, in the form of yellow masses, usually softened in the central parts. This is associated with tuberculosis in other parts, usually in the lungs. In adults, phthisis pulmonalis is frequently associated with a few tubercles in the kidneys as well as in the liver, but they are of comparatively small size.

In **Acute general tuberculosis** there are numerous tubercles in the kidneys, mostly in the cortex. They are usually elongated in shape and visible to the naked eye as small pale areas. Under the microscope they are found to be caseous in their central parts while peripherally their cells infiltrate between the tubules.

Literature.—Négel, De la syph. rénale, 1880; Seiler, Deutsch. Arch. f. klin. Med., xxix.; Curt Jani und Weigert, Virch. Arch., ciii., 522, 1886; Hanan, ibid., ciii., 221, 1887; Nasse, ibid., cv., 173, 1886; Baumgarten, Tuberculose, 1885; Hamill, Pepper Lab. of Clin. Med., Philadelphia, 1896; Delamare, Gaz. d. hôp., 1900.

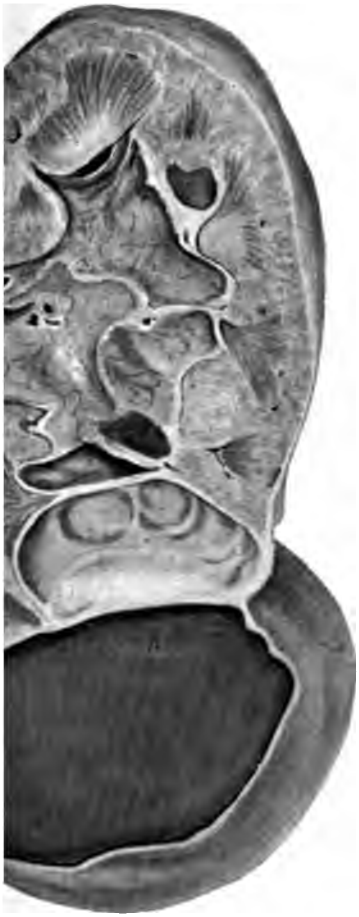
XI.—TUMOURS OF THE KIDNEY.

Fibromas are very frequently met with in the pyramids of the kidney in the form of small white tumours of no practical significance, but they have also been found of large size. **Lipomas** are rare in the kidney, but the fatty external capsule sometimes forms a bulky tumour (*Lipoma capsulare*).

Cysts.—Cysts of various kinds are of peculiarly frequent occurrence in the kidneys, and they are of various kinds. In some cases they arise distinctly from obstruction of the tubules, as in the contracted kidney of interstitial nephritis already mentioned.

Simple cysts are frequently met with in kidneys which are otherwise perfectly normal, and the cysts themselves do not, as a rule, seriously interfere with the functions of the organ. They are larger or smaller well-formed cysts, which not infrequently project from the surface of the organ. They contain usually a clear fluid, but the contents are sometimes colloid in character. The wall of the cyst is composed of connective tissue lined with a proper tesselated epithelium. These cysts sometimes grow to a large size (see Fig. 664), and may push aside the renal tissue to a large extent. It is probable that they are of congenital origin, arising by an isolated occurrence of the same process as that which produces the following form.

Cystic transformation of the kidneys is also a condition of congenital origin, at least in many cases, and probably in all. The whole kidney is converted into a congeries of cysts of various sizes. The cysts rounded prominences on the surface, and on section (Fig. 665) are seen to replace the renal tissue. The wall of each cyst mposed of a tunica propria with well-formed tesselated epithelium g it. It contains usually a clear fluid, but the fluid may be



—Large cyst projecting from the lower end ey.

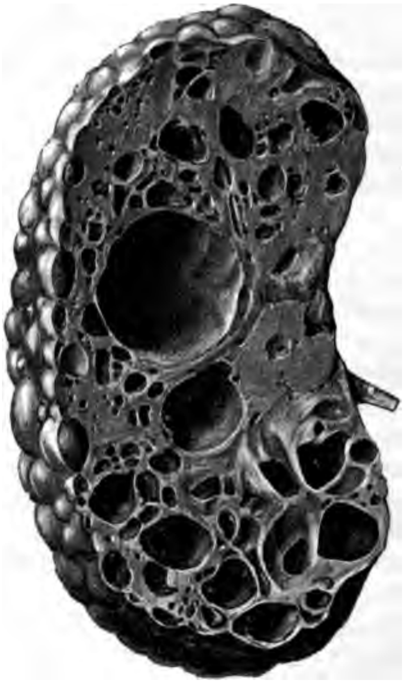


Fig. 665.—Cystic transformation of kidney, shown in section. The other kidney was similar.

nish or even hæmorrhagic, and it is noteworthy that it contains constituents of the urine, often with albumen, and sometimes ws down a granular precipitate of uric acid. Between the cysts is very little space, but there are traces of remaining renal tissue, the pelvis and ureter are present. The outline of the organ is tly enlarged.

Kidneys of this kind have been frequently met with in **new-born children**, in whom they may reach the dimensions of eight inches by four. From their size they may seriously interfere with parturition, even requiring eviceration before delivery can be effected. It is of importance to note that this condition often co-exists with other congenital defects such as hydrocephalus, defective urinary bladder, and horse-shoe kidney, and that it frequently coincides with a cystic condition of the liver.

Cystic degeneration is also met with **in the adult**, and it is remarkable that the functions of the organs may be preserved for a long time, although both kidneys are composed of a congeries of cysts, as in the figure. The author met with a case in which the patient died at the age of forty-three. For eighteen years before his death there had been recurring attacks of hæmaturia, and he at last died with uræmic symptoms. The kidneys were much enlarged and cystic, but with some renal tissue remaining between the cysts.

The cysts undoubtedly arise by dilatation of the uriniferous tubules and glomeruli, the medullary tubules being, according to Kennedy, chiefly concerned. The dilatation is generally ascribed to constriction, so that the cysts are regarded as Retention cysts. There are serious objections to this view. The cysts are obviously growing structures of well-formed tissue, and scarcely like the small dilatations in chronic nephritis. Again, the general aspects of the condition, both clinically and pathologically, are not those of a chronic nephritis such as would produce obstruction. There is rather a slowly advancing transformation of the tubules, without any of the ordinary signs of Bright's disease, so that the actual diagnosis is usually made post-mortem. From his own observation, the author believed that the condition arose probably from a perverted function of the renal epithelium. In a case of the kind he found that the beginnings of the cysts seemed to be the formation of small clumps of colloid matter in the tubules, formed as if by abnormal secretion. The character of the secretion prevented its passage down the tubule, and it may be supposed that the continuation of this abnormal secretion would produce gradual enlargement. An origin such as this would be consistent with the fact that cystic disease of the liver frequently coincides with that of the kidneys, and that in some cases there are also cysts in the pancreas, lungs, etc.

Dermoid cysts are also met with in the kidneys.

Adenoma.—This form of tumour is rare. It occurs in the kidneys in the form of defined solitary growths of various sizes up to that of a walnut or larger. It is found in the cortical substance, and arises from the convoluted tubules. According to structure two forms are described, a papillary and an alveolar, these resembling the corresponding forms in the ovaries (see Fig. 666).

It is common to meet with small tumours consisting of pieces of **Displaced suprarenal capsule.** The tumours, which usually occur as flattened ochre-yellow nodules, lie immediately under the capsule of the kidney, but may be deep in the renal substance; they are distinctly defined from the kidney tissue. Under the microscope they show cylindrical masses of cells which are infiltrated with fat. They are often spoken of as *suprarenal rests*, and special attention was directed to them by Grawitz as starting-points of tumour formation. Grawitz found that certain renal tumours, both benign and malignant, presented marked correspondence with suprarenal gland tissue. He showed that they occurred close under the capsule of the kidney, where suprarenal rests appear, and that the cells of the tumour were perfectly dissimilar from the renal epithelium. He showed, again, that fatty infiltration of their cells was a feature not observed in renal epithelium, but of regular occurrence in the cortex of the suprarenal

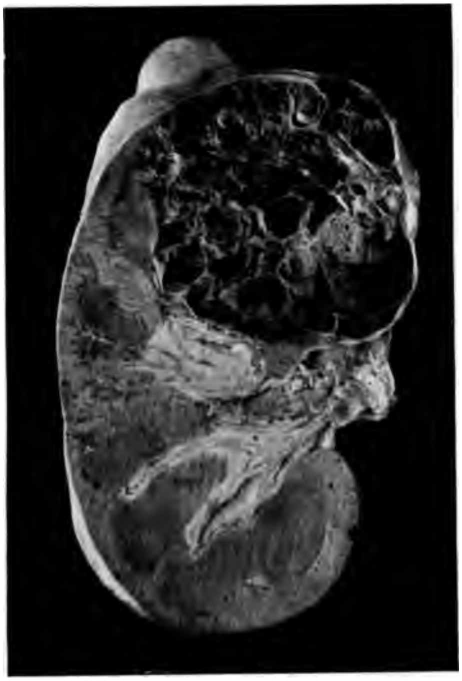


Fig. 666.—Cystic adenoma of the kidney.

gland. The tumours were further shown to be demarcated from the kidney tissue by a connective-tissue capsule, and the correspondence of their structure with one or more zones of the suprarenal gland was emphasized.

A large number of renal tumours adhering to Grawitz's description have been recorded. They grow from the cortex towards the pelvis, and cause atrophy of the renal substance by pressure. They may entirely replace the kidney tissue and still be retained within the capsule. They usually project from the surface, and when of large size consist of a number of nodules, varying in size from a pin's head to walnut or larger. The pelvis is not infrequently invaded, with resulting hæmaturia. The renal vein or vena cava may be involved, and secondary growths may appear in the lungs, liver, bones, etc. Birch-Hirschfeld was the first to apply to these tumours the term **Hypernephroma.** There is no hard and fast line between the benign and the malignant forms.

Microscopically the tumour is seen to be divided up into lobes by connective-tissue bundles continuous with the capsule. From these finer fibrous strands ramify. Necrosis, fatty changes, hæmorrhage, and pigmentation are common, giving the growth a peculiar variegated appearance. The polygonal form of the cells, their size, their arrangement in cylinders and heaps, their close connection with the endothelium of the vessels, their fatty and pigmentary contents, and the sparse stroma—consisting mainly of capillaries—have been adduced in favour of a suprarenal origin. The presence of glycogen (Lubarsch) and lecithin (Gatti) have been specially emphasized. Lubarsch also has laid stress on a certain similarity in staining of the nuclei by Weigert's fibrine stain, with the cells of the suprarenal cortex; on the occurrence of giant cells, which are not uncommon in suprarenal adenomas; on the tendency to invade the venous system, and on the absence of transition from urinary epithelium to tumour tissue. Ulrich and Benekc have shown a direct continuity of tumour with a subcapsular suprarenal. The older nodules were in the upper pole of the kidney.

Tumours of similar structure have been found in other places where suprarenal rests occur, viz.: in the neighbourhood of the spermatic vein, in the broad ligament, in the liver, etc. Further, certain benign and malignant tumours of the suprarenal body correspond closely in structure to the tumours under consideration.

Morphologically these tumours have been variously regarded as adeno-carcinomas, carcinomas, cylindromas, sarcomas, angiosarcomas, endotheliomas, etc. According to M'Vicar, in the character of their cells, cell contents, and stroma, and in their general arrangement, they are most closely allied to endotheliomas of bone. They are of slow growth, and occur for the most part in elderly people.

Primary sarcoma.—This occurs in various forms. It is stated that cases described as cancer are frequently sarcomas (Dickinson). The early age at which cancers of the kidney are stated to occur lends support to this view, as, in general, children are much more liable to sarcomas than cancers (see Fig. 667).

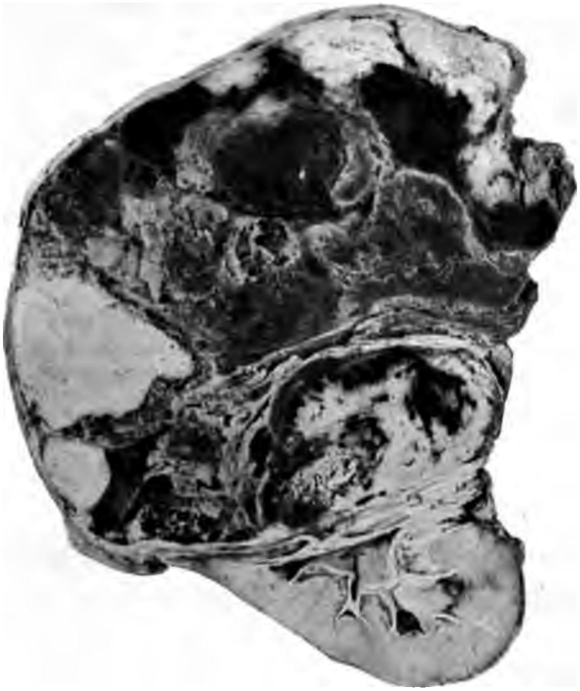


Fig. 667.—Sarcoma of the kidney in a child.

The forms chiefly met with are round-celled and spindle-celled sarcoma, myxosarcoma, and myosarcoma. The tumours generally grow rapidly and may assume large dimensions. They occur mostly in early life.

The **Myosarcoma** is a specially interesting form. It is composed of round or spindle-celled tissue, with which is mixed striped muscle in the form either of elongated cells or cylinders. The tumour is probably congenital in its origin, being only met with in very young children (under eighteen months). It grows rapidly and is usually bilateral.

The view of Cohnheim is probably correct, that the tumours arise by fœtal inclusion. The first rudiment of the uro-genital organs is close to the proto-vertebræ, and it seems probable that some of the germinal muscle cells from the latter have been included with the cells forming the rudiments of the kidney, and have afterwards formed the tumours. Metastasis has been observed, and the secondary tumours may contain muscle.

Primary cancer.—This tumour is usually unilateral, although there have been cases of bilateral cancer. The tumour is in most cases virtually a cancerous degeneration of the organ. The kidney may be completely converted into a tumour, which sometimes attains a very large size, retaining the general shape of the organ and covered by its capsule. The pelvis is also usually recognizable, although the cancerous tissue may have grown into it. But in some cases only a part of the kidney is involved, and in that case, while the affected part retains the general shape of the organ, although enlarged, the remaining piece of kidney has quite its normal appearance. To the naked eye it is as if a portion of kidney were transformed, and with the microscope it can be seen, at the margin of normal and pathological, that the tumour is advancing by a conversion of the proper kidney tissue. The epithelium of the tubules is multiplying so as to form the cancerous epithelium, and is becoming irregular in form, while the cancerous stroma is being formed of the connective tissue of the organ.

In regard to the form of cancer, there are some cases in which the structure has been that of the cylinder-celled epithelioma, in others more that of ordinary cancer. A partial colloid transformation has been observed in a few cases. Whatever the form the tissue seems to originate from the kidney structures.

The tumour is usually very soft, but it is generally confined within the capsule of the kidney. If it passes beyond the capsule it does so more readily into the retroperitoneal tissue than into the peritoneum, and it may thus extend along the wall of the trunk into the pleura.

The growing tumour not infrequently extends into the pelvis of the kidney and the renal veins. Hence arise hæmaturia on the one hand, and thrombosis of the veins on the other. The thrombosis may be very extensive, the clot propagating itself in various directions.

In a case observed by the author there was a very extensive thrombosis, involving the veins of both legs. In another case cancerous elements were present in the thrombus, and some of these had been conveyed to the lungs; they were detected along with the clot inside the pulmonary artery, embolism having occurred.

Secondary Tumours.—Metastatic tumours are not very frequent in the kidneys. **Cancers** and **Sarcomas** occur. **Melanotic sarcoma** also occurs.

Malignant lymphoma and **Leukæmic** tumours are perhaps the commonest. As seen with the naked eye, they form rounded tumours affecting the cortex chiefly, and causing great enlargement. Under the microscope they present round-celled tissue infiltrated between the tubules.

Literature.—*Tumours*—Kelynack, Renal growths, 1898; Jores, Lubarsch & Ostertag, Ergebnisse, vi., 1901; Morris, loc. cit., 1902. *Cysts*—Rayer, Traité des malad. des reins, iii.; Virchow, Ges. Abhandl., 871; Eve, Path. Trans., xxxi., 164, 1880; Pye-Smith, ibid., xxxii., 1881, and xxxvi., 1885; Thorn, Beitr. zur Genese d. Cystenniere, 1882; Kennedy (with literature), Laboratory Rep., Edinburgh, iii., 1891; Ritchie (summaries of cases), ibid., iv., 1892; Ewald, Verhandl. d. Berlin. Med. Gesellsch., xxii. and xxiii.; von Kalhden, Ziegler's Beitr., xiii., 1893. *Adenoma*—Sturm, Archiv d. Heilk., 1875; Weichselbaum u. Greenish, Oest. Med. Jahrb., 1883; Grawitz, Virch. Arch., xciii., 1883; Marchand, ibid., xcii., 1883; Engelken, Ziegler's Beiträge, xxvi., 1899; M'Vicar, Adrenal tumours of the Kidney, Thesis, Edin. Univ., 1902. *Sarcoma*—Dickinson, loc. cit.; Newman, loc. cit. *Myosarcoma*—Cohnheim, Virch. Arch., lv., 1872; and lxv., 1875; Eve, Path. Trans., xxxiii., 1882; Williams, ibid.; Ribbert, Virch. Arch., cvi., 1886. *Cancer*—Waldeyer, Virch. Arch., lxi. and lxiv., 1875; Pereverseff, ibid., lix., 1874; Ebstein, Deutsch. Arch. f. klin. Med., xxx.; Gairdner and Coats, Glasg. Med. Jour., iii., 1871; Brodeur, Affections du Rein, 1886, p. 170; Newman, loc. cit.; Jores, loc. cit., 1901; Morris, loc. cit., 1902.

XII.—PARASITES IN THE KIDNEY.

The **Echinococcus** is of occasional occurrence, sometimes along with a simultaneous hydatid cyst of the liver. There is here, as in the liver, a large mother cyst surrounded by a distinct connective-tissue capsule, and containing the usual daughter cysts and brood-capsules. The cyst not infrequently bursts into the pelvis of the kidney, and the daughter cysts and heads may be evacuated by the urine. Sometimes by obstructing the ureter they lead to hydronephrosis. Rupture may also occur into the pleura.

Sometimes the parasite dies, and the cyst comes to be occupied by a pultaceous material in which the remains of the laminated membrane are found (Fig. 668). The stratified character of this membrane is here, as in the case of the liver, of assistance in distinguishing the nature of the cyst, especially as all other trace of the parasite, even the hooklets, may have disappeared. The kidney tissue may be considerably opened up and pushed aside by this parasite.

The **Filaria sanguinis** occurs probably in the adult form in the lymphatic vessels of the kidney. The embryos have been met with in the parenchyma of the kidney and in the **Chylous urine,** which is the result of the presence of the parasite (see p. 446).

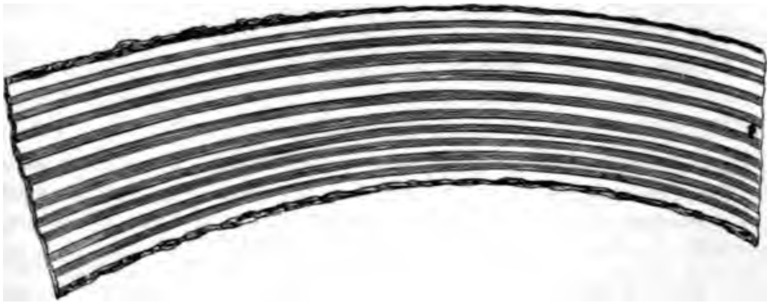


Fig. 668.—Section of a stratified chitinous membrane from an old hydatid cyst of kidney. × 90.

Literature.—Romestau, Des Kystes hydatiques des reins, 1881; Barker, Cystic entozoa of human kidney, 1856; Manson, Filaria sang., 1883; Lewis, Memoirs, 1888. See also Literature, Animal parasites, p. 447.

B.—The Urinary Bladder.

1. **Congenital malformations.**—These are chiefly represented by **Extroversion of the bladder,** already described at p. 55, and **Persistence of the urachus,** which is a minor degree of a similar malformation.

2. **Perforation and Rupture of the bladder.**—Rupture may be produced in various ways. It may be by a direct wound, by fracture of the pelvis, by injuries during parturition. Then ulceration from stone, but more frequently from cancer, not infrequently produces perforation.

The normal urinary bladder may be ruptured by a blow or fall when it is distended with urine. This occurs most readily in intoxicated or insane persons. The rupture occurs usually on the posterior aspect near the fundus and into the peritoneum.

These conditions are important chiefly in their consequences, leading, as they commonly do, to extravasation of urine and to the formation of fistulous communications with the surface or with neighbouring canals.

Simple **Extravasation of urine** is not in itself serious. The normal urine is a bland fluid, and it may flow from a severed ureter or a ruptured bladder into the peritoneal cavity without producing any peritonitis, the urine being absorbed by the peritoneum and again excreted by the kidney. If the aperture remains open then the secreted urine is not removed, but passes back into the peritoneum to be re-absorbed. In this way a vicious circle is established, and death from **Uræmia** is the result. The normal urine does not produce an ordinary peritonitis, but it may lead to a considerable serous exudation, and there are the general symptoms of peritonitis.

When the extravasated urine undergoes alkaline decomposition it acquires excessively irritating characters. The urine being an exceedingly decomposable fluid, and being kept at the temperature of the body, rapidly decomposes if the proper organisms find access to it. Hence from rupture into the peritoneum we may have violent acute peritonitis, or from rupture either of the bladder or urethra into the surrounding connective tissue an acute suppurative inflammation of the areolar tissue and skin, sometimes with extensive necrosis.

Fistulous openings from rupture of the bladder may be into the uterus or vagina, into the rectum, or on to the cutaneous surface. From these fistulæ the urine passes involuntarily as it reaches the bladder, there being no sphincter to retain it. They occur also as a result of perforation of the bladder from without, especially from the uterus and vagina, the cause of perforation being sometimes cancer of these parts, sometimes sloughing from injury during parturition.

3. **Dilatation and Hypertrophy of the bladder.—A simple dilatation** may occur from a sudden obstruction to the urethra, or from paralysis of the muscles concerned in emptying the bladder. In this way a very extreme general dilatation may result.

Hypertrophy of the muscular coat is of very frequent occurrence as a result of some obstruction either at the neck of the bladder or in the urethra. The commonest cause is enlargement of the prostate leading to the prominence of the so-called middle lobe at the internal orifice of the urethra (Fig. 669), but stricture of the urethra is also a frequent cause.

The muscular coat of the bladder is in the form of bundles of muscular fibre-cells which run in special directions. The muscular coat is therefore not a homogeneous layer, but more like a network of interlacing bands. It is so at least when the bladder is distended, the bands coming closer together as the bladder contracts. When hypertrophy occurs these bundles increase greatly in size, and the internal ones raise the mucous membrane into elongated prominences. As the bundles interlace, the result is that the internal surface of the bladder presents a network or prominent trabeculæ which suggest the appearance of the internal surface of a ventricle of the heart, as shown in Fig. 669.

As these trabeculæ interlace, little spaces are left between them in the form of small **pouches**. Sometimes these pouches undergo considerable enlargement, and we may have **Diverticula** formed in this way. The diverticulum is originally formed of the mucous membrane pushed out between the thickened muscular trabeculæ. When small it is contained in the thickened wall of the bladder and emptied during micturition. But as it deepens and projects outside the wall of the bladder it becomes free of the muscular coat, and as it possesses no muscular coat of its own the effect of the contraction of the bladder during micturition will be to force the urine into it, just as it is forced into the urethra. The diverticulum is liable in this case to periodical dilatation. The urine also will stagnate in it, and if decomposition occurs, then there will be inflammatory disturbances in the wall of the diverticulum. New-formation of connective tissue occurs, and, as this tissue is at first soft, the recurring dilatation during micturition causes it to yield, so that a continuous enlargement goes on. The diverticula so formed are usually of small or moderate dimensions, but cases occur in which there is a large sac, usually behind the bladder and communicating with it by a narrow neck (Fig. 670). The sac may be larger than the bladder itself, and it presents a somewhat thick fibrous wall with signs of recent inflammation internally.

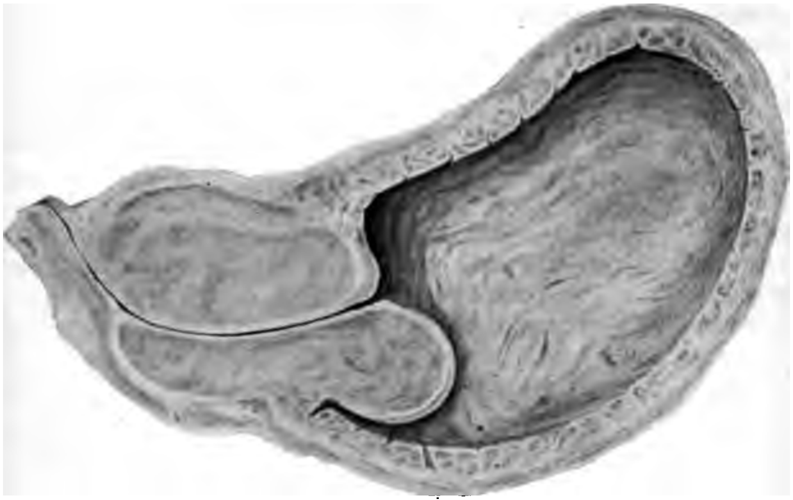


Fig. 669.– Hypertrophy of the bladder from enlargement of the prostate.

In diverticula of moderate or large size calculi are liable to form from stagnation of the urine. Or a calculus may slip into such a pouch and escape detection with the sound.

4. **Disturbances of the circulation of the bladder—Passive hyperæmia** occurs in consequence of obstruction of the veins by tumours in the abdomen or otherwise. Sometimes in such cases the veins of the mucous membrane undergo great dilatation and become varicose, especially in the floor of the bladder, giving rise to **Vesical hæmorrhoids.** The dilated veins may even obstruct the orifice of the urethra, and there is sometimes hæmorrhage from them.

Hæmorrhage from the bladder occurs also in consequence of the irritation of calculi, from tubercular ulcers, from papillary and cancerous tumours. There may be hæmorrhages from the mucous membrane in scurvy, hæmorrhagic small-pox, etc. There is sometimes a hæmorrhage following catheterization, and probably due to the sudden relief of pressure from the emptying of the bladder, without a sufficient contraction of the muscular coat. If the bleeding into the bladder be considerable the blood may coagulate, and may be discharged with some difficulty. Or it may mix itself with the urine, and no consistent coagulum be formed.

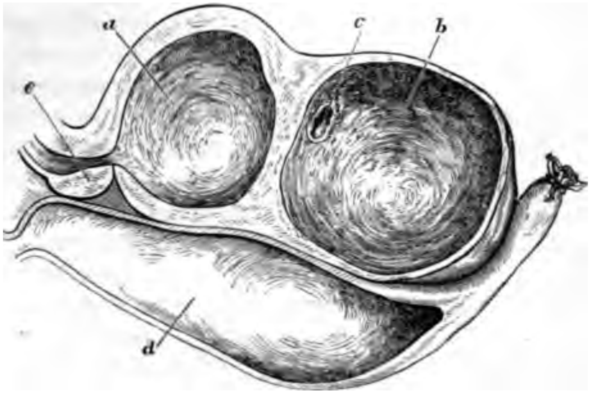


Fig. 670.—Large diverticulum of urinary bladder: *a*, bladder with greatly thickened wall; *e*, prostate and prostatic urethra; *b*, diverticulum with fibrous wall; *c*, aperture between bladder and diverticulum; *d*, rectum. (From a preparation in Museum of Western Infirmary, Glasgow.)

5. **Inflammation of the bladder. Cystitis.**—This occurs as a consequence of various kinds of irritation. Stone may produce it, and so may the extension of gonorrhœa, but by far the most frequent cause of it is alkaline decomposition of the urine.

The decomposition is due to the introduction of microbes and their propagation in the contents of the bladder. They are usually introduced by the catheter. In a healthy bladder such introduction may produce no effect, the growth of the microbes being inhibited by the normal mucous membrane. In cases of paralysis of the bladder, or of dilatation, especially when combined with a certain amount of inflammation, the microbes multiply. This is particularly the case when there is stagnation of the urine, and the bladder has to be relieved at intervals by catheterization. The bacteria may find other means of entrance, as by fistulous openings. It is not impossible that in the case of the short female urethra they may propagate along that passage from the vagina.

The products of decomposition produce the usual inflammatory manifestations in various degrees. In very acute cases there is great swelling of the mucous membrane, it may be with superficial or deep sloughing (Fig. 671). In more chronic cases the mucous membrane becomes thickened and very frequently the seat of ulceration, so that with thickening and ulceration there is very great irregularity of the surface, sometimes with polypoid projections. The surface is occasionally incrusted with phosphates deposited by the alkaline urine. The muscular coat is often thickened, especially when there is at the same time obstruction to the passage of the urine, and there is the usual trabecular appearance, but obscured by the thickening of the mucous membrane. The bladder may undergo great contraction in consequence of chronic inflammation, the new-formed tissue in the mucous membrane shrinking.

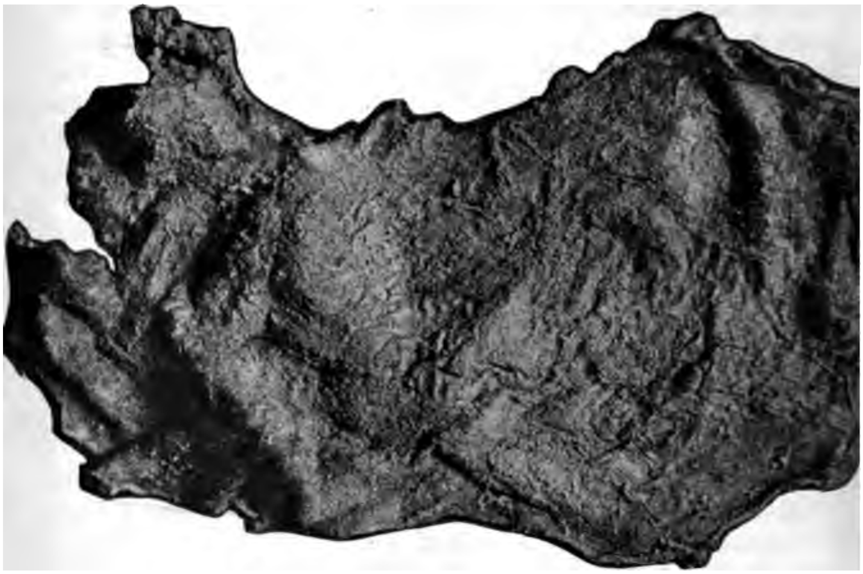


Fig. 671.—Slough of the mucous membrane of the bladder.

The urine contains the inflammatory exudation as well as the products of decomposition. In acute cases there may be considerable quantities of pus. In more chronic cases the urine is thick and gelatinous like a mucous secretion. The toughness does not, however, depend on the presence of mucin, but is occasioned by the albumen of the inflammatory exudation being acted on by the alkaline salts in the urine. It is well known that the presence of pus in the urine may be detected by adding an alkali; the deposit assumes a gelatinous character. The pus and other inflammatory products in the bladder are similarly acted on when the urine becomes alkaline, and we have the viscid character mentioned. Under the microscope the urine presents abundant pus corpuscles and epithelium, with immense numbers of bacteria and crystals of triple phosphates.

Decomposition of the urine in the bladder is of consequence, not only in respect that it leads to Cystitis, but also that the decomposition is liable to extend upwards and produce still more serious effects. Thus the process may extend up the ureters so as to produce one of those serious septic conditions of the pelvis and kidney already described (see p. 1102). These results sometimes follow the introduction of a catheter so rapidly as to have given origin to the term **Catheter fever**, a clinical designation which may include one or other of the conditions described under the designations Pyelitis, Pyelonephritis, Suppurative Nephritis, and Pyonephrosis.

6. **Tuberculosis of the bladder.**—This condition is usually only a part of much more extensive tuberculosis. There is often a coincident tuberculosis of the kidney and ureter (see above). The vesiculæ seminales, vas deferens, and testicle are frequently affected, and the bladder affection is often due to propagation from the testicle.

The tuberculosis is in the form of ulcers of the mucous membrane which at first are circular, but acquire various shapes by coalescence (Fig. 672). The ulcers are mostly superficial and their edges very slightly raised, the latter having a pale colour so that the ulcer is surrounded by a whitish zone. The disease begins by the formation of tubercles in the mucous membrane. These break down and form ulcers, which continuously extend by the further tuberculosis of their walls and the breaking down of the infiltration. The general appearances of these ulcers are very well shown in the annexed figure from Virchow's work on tumours. Their superficial character renders them liable to be overlooked.

7. **Tumours of the bladder.**—A few cases of **Fibroma** and **Myoma** have been described, but they are rare.

Villous Papilloma is a much commoner tumour (see Figs. 150, 151, p. 317). This is met with for the most part in the inferior portions of the bladder, and forms either a prominent mass with projecting papillæ or else a surface covered by villi. The tendency of these villi to bleed is an important fact. Sometimes the villi break down and an ulcer forms. In any case they discharge abundant epithelium, which is to be found in the urine, and is not to be taken as evidence of the existence of cancer.

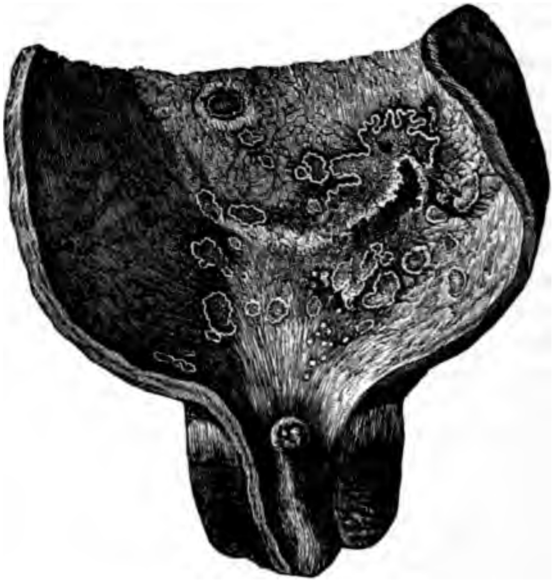


Fig. 672.—Tuberculosis of the bladder. Many round or serpiginous ulcers are shown. These are superficial, but are defined by their white edges which represent recent tubercles. There are several white spots, indicating tubercles which have not yet ulcerated. (VIRCHOW.)

Cancer of the bladder is mostly met with in the form of villous cancer. The surface is like that of the Papilloma, but the wall of the bladder beneath the villi is infiltrated with the cancerous structures. In some cases the structure gives way and a cancerous ulcer with raised edges is the result. There are also cancers without any villous projections of the surface. These may form very insignificant tumours and yet lead to very widespread secondary extension. The cancer may extend to neighbouring structures, but it is much more common for a cancer originating in the uterus or the rectum to extend into the bladder than for the reverse process to occur. We have already seen that fistulous communications occur in this way.

Cysts have been found, especially in the posterior wall of the bladder. In cystitis the writer has several times found a number of small cysts in front of the trigone, a condition to which the name **Vesiculation of the bladder** has been given (see Fig. 673).

8. **Parasites.**—If we except the microbes already referred to, parasites in the bladder are of secondary importance. The echinococcus may burst into the pelvis of the kidney, and portions of the parasite pass into the bladder. Ascarides and oxyurides have been found to wander into the bladder. The distoma hæmatobium, by the penetration of its ova, produces considerable irritation and hæmorrhage.

Sarcinæ have been found in the urine in cases of inflammation of the bladder, but rarely.

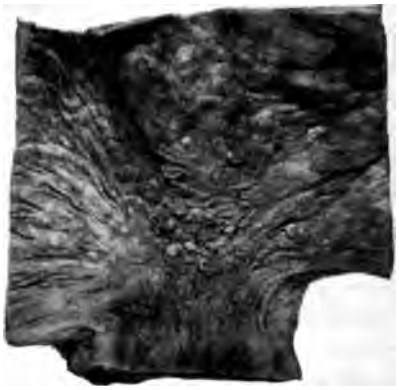


Fig. 673.—Vesiculation of the mucous membrane of the bladder.

9. **Concretions and Calculi in the bladder.**—The most frequent constituents of urinary calculi are phosphates, uric acid and oxalate of lime. Phosphates are precipitated from alkaline urine, uric acid and oxalate of lime from acid urine. Phosphates are deposited abundantly when urine, after being passed, undergoes its usual alkaline decomposition; uric acid and oxalates are thrown down in crystals when the urine, at the time of evacuation or afterwards, is unduly acid, the deposition of oxalates occurring usually some time after the urine has been passed, so that this precipitate often, as it were, powders the surface of other deposits.

Inside the bladder or the pelvis of the kidney, **phosphates** may be deposited because of undue alkalinity, especially in the case of alkaline decomposition of the urine. These often form an external coating on other stones when, from decomposition, the urine has become alkaline. Phosphates are also frequently deposited on foreign bodies which have found their way into the bladder.

The precipitation of **Uric acid and Oxalate of lime** seems sometimes due to their excess in the urine. This applies especially to the oxalates, there being individuals in whom an excess of oxalate of lime is almost always present in the urine (oxalic acid diathesis). But in both cases the substances are deposited from an acid urine, and in the case of uric acid it must be strongly acid. The cause of this abnormal acidity is not always clear. In some cases it may be due to excessive development of acid in the stomach.

The formation of calculi of uric acid and oxalate of lime seems always to begin in the kidney, and even in some cases in the uriniferous tubules. In the tubules and in the pelvis it is common to find small concretions of uric acid, forming the so-called **Sand or gravel**, composed of aggregates of uric acid crystals, usually rounded in shape and of a brownish red colour. There may even be large concretions of uric acid in the pelvis of the kidney. In connection with the formation of the uric acid and oxalate calculi it is interesting to observe that the two bodies are often combined in one calculus, the mulberry stone especially having frequently a nucleus of uric acid, and perhaps layers of it alternating with the oxalate of lime.

Forms of calculi.—We give here a brief description of the different forms of calculi, with an indication of the chemical methods for determining their constitution. As a rule it is convenient to have the calculus sawn through the middle with a lapidary's saw, so that the arrangement of its layers and the characters of its nucleus may be seen.

1. **The uric acid calculus.**—This is usually a small oval stone, with rounded prominences regularly distributed over the surface. The colour varies from a light fawn to a deep brick red. It is heavy for its size, and of hard consistence. Uric acid is insoluble in water and dilute acids, but very soluble in weak solutions of caustic alkalies and alkaline carbonates. A convenient test is the *murexid* reaction. A fragment of the calculus is treated with a drop of strong nitric acid and heated. Effervescence occurs, and the heat is continued till a dry yellowish red residue remains. When strong ammonia is added to the residue a bright violet red hue is developed.

Calculi formed of **urates** are rare, the salts being urates of ammonia and magnesia. They are small soft concretions formed in the kidney, and are distinguished by their solubility in boiling water. They hardly deserve to be reckoned among the vesical calculi.

2. **The Oxalate of lime or Mulberry calculus.**—Sometimes small stones are discharged as gravel, forming smooth, round, greyish balls like hemp seeds. The calculus proper is mostly of an irregularly spherical shape, tuberculated on the surface like a mulberry, and of a greyish or nearly black colour. On section it is seen to be in layers, some of the latter generally composed of uric acid, which also usually forms the nucleus. The calculus contains abundant organic material which holds the colouring matter, so that when the oxalate of lime is dissolved out the organic basis often retains the shape of the calculus. Oxalate

of lime is insoluble in the alkaline carbonates and organic acids, but soluble in nitric and hydrochloric acids. If a fragment be heated on a piece of platinum before the blow-pipe it becomes black, swells up and leaves a bulky white ash of caustic lime which gives a strong alkaline reaction to litmus.

3. **The Basic phosphate of lime calculus.**—This form is very rare. It occurs as comparatively small yellowish or greyish white stones, rather hard and smooth on the surface.

4. **The Mixed or Tribasic phosphatic calculus** is very common, at least many calculi are partly formed of phosphates, although few are so entirely. The phosphates are deposited from alkaline urine as a light, bulky, white substance, which is commonly very brittle. The salts are insoluble in water and alkalies, but are very soluble in acids. When a fragment is heated in the blow-pipe flame, the salts melt and form a hard enamel; hence this form is often called the **Fusible calculus**.

5. **The Carbonate of lime calculus** is rare. It forms small, round, soft stones. The salt dissolves with effervescence on adding an acid, leaving an organic matrix of the shape of the stone.

6. **The Cystine calculus.**—This occurs only in persons who are subjects of **Cystinuria**. It appears as if, by a congenital derangement of the nutritive processes, such persons form cystine, to a certain extent probably in place of uric acid; and this peculiarity occurs frequently in several members of the same family. The urine, continuously or frequently, contains flat hexagonal crystals of cystine, and these may be already present in the urine at the time of evacuation, or may be deposited after the urine has stood for a time. The cystine may begin to be deposited in the uriniferous tubules so that calculi are formed in the pelvis of the kidney, or it may be deposited in the bladder. The stones are oval in shape and have a waxy consistence. The surface is brownish or greenish yellow in colour, and crystals can often be separated from it. The stone may be buried in a shell of phosphates. Cystine is soluble in alkalies, mineral acids, and oxalic acid.

7. **Xanthine calculi** are exceedingly rare. The substance is allied to uric acid, and the stones are like those of uric acid but of a redder colour. On applying the murexid test to a fragment of such a stone, it is found to dissolve in nitric acid but without effervescence; the addition of ammonia gives an orange colour.

Literature.—*Rupture*—Rivington (with literature), Rupt. of urinary bladder, 1884; Coats, Brit. Med. Jour., 1894, ii., 121. *Cystitis*—Ebstein, Ziemssen's Handb., ix.; Du Mesnil (Gonorrhœal infl.), Virch. Arch., cxxvi., 1891. *Tuberculosis*—Krzywicky, Ziegler's Beitr., iii., 1888; Chavasse, Étude sur la tub. des org. urinaires, 1872; Voisin, Bull. de la soc. anat. de Paris, xlix., 1874; Englisch, Wiener Klinik, 1896; SENN, Tuberculosis of genito-urinary organs, 1898. *Tumours*—THOMPSON, Tumours of bladder, 1884; KÜSTER, Volkmann's klin. Vortr., 267, 268, 1886; ALBARAN, Tum. de la vessie, 1892; CAHEN (Cystadenoma, cancer), Virch. Arch., cxiii.; TSCHISTOWITSCH (Growth of papilloma), ibid., cxv.

DISEASES OF THE URETHRA.

Injuries to the urethra are chiefly important on account of their tendency to lead to stricture. Falls on the perinæum when sufficiently severe to fracture the pelvis, usually cause rupture of the urethra. This is followed by extravasation of urine, which may lead to serious results. In case of recovery the wound in healing draws together, and leads to stricture, which may even amount to obliteration of the canal.

Injuries are also frequently inflicted from within by the passage of bougies and catheters.

Inflammations.—The most frequent form is **Gonorrhœa** which we have seen to result from the action of the gonococcus (p. 159). The mucous membrane in the acute stage is red and swollen, and there is a purulent discharge, mixed with blood. The inflammation sometimes extends to the surrounding connective tissue or to the spongy tissue of the penis. Abscesses may be so formed, and in some cases a thrombo-phlebitis occurs, with resulting pyæmia. It may also extend to the bladder. The acute stage passes off and usually leaves a chronic inflammation which frequently results in stricture.

Other forms of inflammation are rare. There may be a simple catarrh, especially in the female urethra, propagated probably from the vagina.

Stricture.—Obstruction of the urethra occurs, as we have seen, in consequence of injuries. As it is mostly the membranous part of the urethra which is torn, the resulting stricture has its seat there.

Enlargement of the prostate is the cause of obstruction, but scarcely of stricture of the urethra (see under diseases of the male organs).

Gonorrhœa is the most frequent cause. The chronic inflammation, which so frequently remains after the acute stage of gonorrhœa, commonly concentrates itself in the most dependent part of the canal, which is the point of union between the membranous and spongy portions or the first part of the spongy portion. Here the mucous membrane remains swollen, and, as the chronic inflammation continues, connective tissue is formed, both in the mucous membrane and for some distance around. The new-formed tissue is, as in other cases of chronic inflammation, dense, and possesses a tendency to contract. Its contraction narrows the canal, which may be found embedded in an exceedingly dense, almost cartilaginous tissue. There is seldom an actual obliteration of the canal, such as occurs more readily in traumatic stricture.

In cases of stricture **False passages** are frequently formed by the catheter. These have their aperture near the stricture, and after burrowing through beneath the mucous membrane, either join the urethra on the proximal side or pass on to the neck of the bladder before forming a communication.

The urethra is **dilated** on the proximal side of the stricture, and this dilatation may be propagated to the bladder, and sometimes to the ureters and pelvis of the kidney. Sometimes the dilatation of the urethra, by widening the neck of the bladder, causes paralysis of the sphincter. Hypertrophy of the bladder is a common result of stricture.

Tumours are very rare in the urethra. **Carunculæ** are limited polypoid outgrowths from the mucous membrane, of somewhat rare occurrence. **Tuberculosis** occurs in association with the same disease of the bladder, prostate and vesiculæ seminales. **Cancer** is met with chiefly in the deep parts of the urethra by extension from prostate or bladder, and in the distal parts by propagation from the glans penis.

SECTION X.

DISEASES OF THE GENERATIVE ORGANS.

Hermaphroditism, implying co-existence of both sexes, chiefly a Pseudo-hermaphroditism in various forms.

SUBSECTION I.—DISEASES OF FEMALE ORGANS.

A. **Vulva, Vagina, Uterus, Fallopian Tubes, and Ovaries.**—I. **Affections of Vulva and Vagina, of Uterus**, etc. II. **Malformations**—1. Defective formation. 2. Duplicity of uterus and vagina. III. **Displacements of Uterus**—1. Prolapse or descent. 2. Prolapse of vagina. 3. Inversion of uterus. 4. Flexions and versions. 5. Other displacements. IV. **Thrombosis and Hæmorrhage.** V. **Atrophy, Hypertrophy, and Dilatation of Uterus.** VI. **Inflammations**—1. Of the uterus, (*a*) Endometritis, (*b*) Metritis; 2. Around the uterus, (*a*) Salpingitis, (*b*) Perimetritis, (*c*) Oophoritis, (*d*) Parametritis. (Puerperal fever.) VII. **Extra-uterine pregnancy**, chiefly tubal. VIII. **Syphilis and Tuberculosis.** IX. **Tumours of Uterus.** 1. Myoma, 2. Cancer, 3. Sarcoma, 4. Polypi and Adenomata. X. **Tumours of ovaries and broad ligament**—Introduction, 1. Simple cysts, 2. Colloid ovarian cystoma, 3. Papillomatous cysts of ovary, 4. Cysts of broad ligament and Parovarium, 5. Dermoid cysts, 6. Cancer, 7. Sarcoma. (Tubo-ovarian cysts.)

B. **Fœtal membranes and placenta.**—1. Affections of decidua. 2. Hydatid mole. 3. Diseases of placenta. 4. Deciduoma malignum.

C. **Mammary gland.**—I. Malformations, Inflammations, etc. II. Tumours. 1. Adenoma and Fibroma, 2. Myoma, 3. Sarcoma, 4. Cancer in various forms, 5. Cysts. III. Parasites.

SUBSECTION II.—DISEASES OF MALE ORGANS.

A. **Testicle and Tunica vaginalis.**—1. Malformations and Misplacements, 2. Inflammations, 3. Syphilis, 4. Tuberculosis, 5. Tumours, including cysts, sarcomas, enchondromas, and others, 6. Hydrocele, 7. Spermatocele.

B. **Penis, Scrotum, and Prostate.**—Their various diseases.

HERMAPHRODITISM.

THIS name implies the union of the two sexes in the same individual. So far as the internal organs are concerned such a condition is rendered possible by the fact that in every fœtus the embryonic structures for both sexes are present at a certain period of development; the Wolffian ducts go to form the male, and the Müllerian ducts the female organs. It is by the subsequent retrogression of one of these and the preponderance of the other that the sex of the child is determined. Though the proper glands are scarcely represented in the opposite sex, yet the gland-ducts or passages are preserved as rudiments. Thus in the female the parovarium represents the epididymis, whilst in the male the hydatid of Morgagni represents the Fallopian tube and the vesicula prostatica the uterus.

A **True hermaphroditism**, in which ovary and testicle are both represented in the same individual, is possible, and cases have been recorded in which on both sides both of these glands have been present, one or other of them, however, generally ill-developed. This would form a true **Bilateral hermaphroditism.** On the other hand, there may be a testicle on the one side and an ovary on the other, forming a true **Lateral hermaphroditism.** It is necessary, however, in such cases to be careful, and not to conclude that an organ is testis or ovary from its mere position, but to subject it to microscopic examination.

Pseudo-hermaphroditism is more common. In it the existence of testicles or ovaries determines the sex to be male or female, but other parts are developed so as to resemble those of the opposite sex, and so produce an apparent combination.

In **Male pseudo-hermaphroditism** the testicles are present, but the other structures, in whole or in part resemble those of the female. Three combinations are distinguished.

(*a*) *Complete male pseudo-hermaphroditism* is the condition in which, while the glands are the testes, all the remaining organs, both internal and external, resemble those of the female. This arises by a persistence of Müller's ducts and an imperfect closure of the urethra. It may here be remarked that as the external generative organs arise from the same fœtal structures in both sexes, they cannot really represent both the female and the male sexes in the same person. But as the male organs present as it were a further development, chiefly consisting in enlargement of the clitoris and closing in of the urinary passage to form a urethra, we may, by arrest of development, have more or less of an approach to the condition of the female organs.

(*b*) *Internal male pseudo-hermaphroditism* comprises cases in which the external organs are those of the male and the testes are present, but from the prostatic urethra a canal arises which represents an elementary vagina with a uterus at its extremity, sometimes with Fallopian tubes. The uterus may be of the regular form but small, or it may be two-horned, or with one horn and a Fallopian tube. We have already seen that the vesicula prostatica is the representative in the male of the vagina and uterus, and the condition we are now considering is an exaggeration of that pouch due to an unusual persistence of the lower part of Müller's ducts. There may be all degrees of this persistence, but the case is not one of pseudo-hermaphroditism unless there is something that can be called a vagina and uterus, even if very rudimentary.

(*c*) *External male pseudo-hermaphroditism* is characterized by the external organs presenting the characters of those of the female while the entire internal organs are those of the male. The cases are to be excluded in which there is simply an opening up of the urethra (hypospadias) from arrest of development. There must, in addition, be an approach in the form of the organs to those of the female. At the same time the general form of the body is that of the female. Several such cases have been married as females, and the true sex only discovered afterwards, even as late as the death of the person.

Female pseudo-hermaphroditism is of much rarer occurrence than male, and is susceptible of similar division. In all these forms there are ovaries, and the variations are in the other organs.

(*a*) *Complete female pseudo-hermaphroditism* presents the male form of the external organs as well as a portion of the male internal organs, while the ovaries are the glands present. In one case the male organs were complete as far as the prostate, but from this sprang vagina, uterus, and Fallopian tubes.

(*b*) *Internal female pseudo-hermaphroditism* is that in which, with well-developed female organs both external and internal, there are male organs present from the persistence of the Wolffian ducts, tubes passing from the parovarium to the uterus or vagina. This condition is excessively rare, although in ruminating animals it is a normal condition.

(*c*) *External female pseudo-hermaphroditism* is the form in which the external parts have the characters of the male while the internal have those of the female. It will be understood that an elongation of the clitoris will cause the parts to approach to those of the male. Some cases present nothing more than this, while there are others in which there is a distinct penis, and the opening of the vagina is narrow and concealed. The name hermaphrodite can hardly be applied unless there is, as well, a type of body approaching that of the male. A case is recorded in which the real sex was only suspected when the person became pregnant.

Literature.—FÖRSTER, Missbild. des Menschen, 1861; GUNTHER, Commentatio de Hermaphroditismo, 1846; BALLANTYNE, Encycl. Med., iv., 1900.

SUBSECTION I.—DISEASES OF THE FEMALE GENERATIVE ORGANS.

Introductory.—The female organs are specially liable to disease from their functional relations. At the times of menstruation and pregnancy changes occur, some of which, although strictly physiological, border on the pathological. The anatomical relations of the internal organs of generation in the female have also to be taken carefully into account in connection with the changes in position to which the uterus is especially liable.

A.—VULVA, VAGINA, UTERUS, FALLOPIAN TUBES, AND OVARIES.

I.—AFFECTIONS OF THE VULVA AND VAGINA.

Malformations of the vulva are occasionally seen varying from complete absence to union of the labia minora or labia majora. The latter is not uncommon in young children. A similar union may result from inflammatory adhesion.

Hyperplasia sometimes is met with. The excessive development of the labia minora and clitoris in certain races (*Hottentot apron*) is an example of this.

Passive Hyperæmia and **Œdema** are common manifestations, and the subcutaneous rupture of the dilated veins may give rise to a hæmatoma.

Inflammatory manifestations like those involving the skin generally are common. Amongst the most important are gonorrhœal vulvitis and the severe inflammations associated with diphtheria and other infective processes.

Leucoma, similar to the condition met with in the tongue, is seen often as a precursor or concomitant of cancer.

Kraurosis vulvæ is a comparatively rare affection; the ætiology of which is obscure. It develops in cases of long-standing pruritus. It results in the formation of connective tissue, which shows a great tendency to contract, causing often striking stenosis. The surface epithelium is usually much altered, presenting the pearly white appearance seen in macerated skin.

Noma, similar in character to the cancrum oris of children, has been repeatedly observed.

Syphilis in its primary and secondary manifestations is common in the vulva; in its tertiary stage it is rare.

Tuberculosis is exceedingly rare, and practically always secondary.

Elephantoid hypertrophy and pedunculated fibromata or myxomata have already been referred to (see page 284, and Figs. 111 and 112).

Amongst the malignant tumours **Cancer**, in the form of flat-celled epithelioma, is much the most frequent and important. It may assume a nodular, papillary, or ulcerous form.

Congenital and acquired deformities of the vagina.—The more important of the former will be considered later; the latter do not call for special mention.

Inflammations of the vagina.—The most frequent of these are the catarrhal forms: the most important is gonorrhœal vaginitis. Other forms are described, such as aphthous, emphysematous, etc. Diphtheria has occasionally been observed.

Syphilis is met with in all its stages. **Tuberculosis** is rare, and almost always secondary.

Tumours.—**Cysts** arising in connection with the Wolffian or Müllerian duct (Gærtner's duct) or from the glands are met with. **Myomas** and **Fibromas** are occasionally seen in the anterior wall. **Sarcomas** may occur in children as polypoid or nodular growths, which are probably congenital, or in adults in the form of more diffuse infiltrations. **Cancer** is not uncommon, both primary and secondary by involvement from neighbouring parts. Metastasis of **Deciduoma malignum** to the vagina has been repeatedly observed.

II.—MALFORMATIONS.

In treating of this subject it is necessary to bear in mind that the internal and external organs have separate developmental origins, and that the malformations of the one may have no connection with those of the other.

1. **Defective formation of the female organs.**—Defects of various kinds are met with, both in the internal and external parts. The ovaries may be wanting or may remain rudimentary. The uterus may be wanting, and with it the Fallopian tubes; or it may be quite rudimentary (Fig. 674), presenting perhaps a solid rudiment, or merely two diverging horns. With this the vagina is often defective. Then the uterus may retain in the adult the fœtal or infantile form. Again, the uterus or vagina may be imperforate, or the hymen imperforate. There are also various defects of the external organs, as absence of the vulva, the vagina and urethra opening by a small aperture in the region which the vulva should occupy. The hymen may be absent, or it may present fimbriated processes sometimes so large as to project externally.

The **Uterus unicornis** occurs when one Müller's duct is ill-developed. The uterus is a long thin structure which curves to one side, while the other horn is absent or rudimentary (Fig. 675).

2. **Duplicity of uterus and vagina.**—The ducts of Müller in the embryo are destined to form the vagina, uterus, and Fallopian tubes, and they are at first double from end to end. The fusion of the ducts occurs first at their lower extremities so that the vagina and lower part of the uterus early form a single canal. Up to the end of the third month, however, the uterus possesses two horns, the subsequent fusion proceeding from below upwards. In many animals this bilateral duplicity persists during life, so that the adult uterus has two horns, often of great length. The duplicity may persist in different degrees in the human subject presenting various forms.

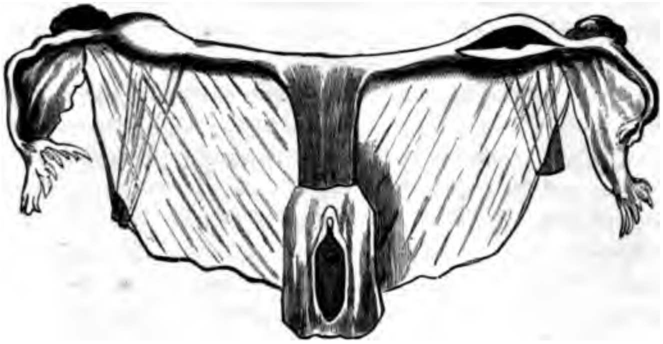


Fig. 674.—Rudimentary uterus. (GRAILY HEWITT from KUSSMAUL.)

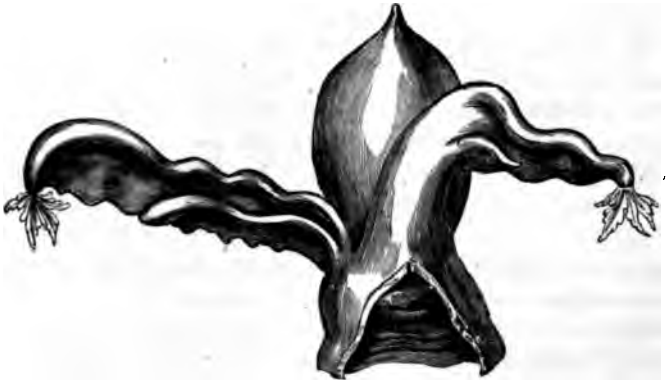


Fig. 675.—Uterus unicornis. The parts are viewed from behind, and the distended bladder occupies the background. The right horn is large, and runs into the Fallopian tube whose fimbriated extremity is shown. There is no proper left horn, the Fallopian tube and round ligament springing from the base of the right horn. (GRAILY HEWITT from KUSSMAUL.)

(*a*) *Uterus separatus didelphys* is the most extreme degree of duplicity. The ducts have remained separate, so that from the fimbriated extremities of the tubes to the external orifice of the vagina there are two separate canals. The canals may be partially adherent externally, but their walls have not coalesced and they appear externally as two separate tubes. This malformation does not occur except with other deformities, most frequently with extensive fission of the abdomen, and the fœtus does not survive.

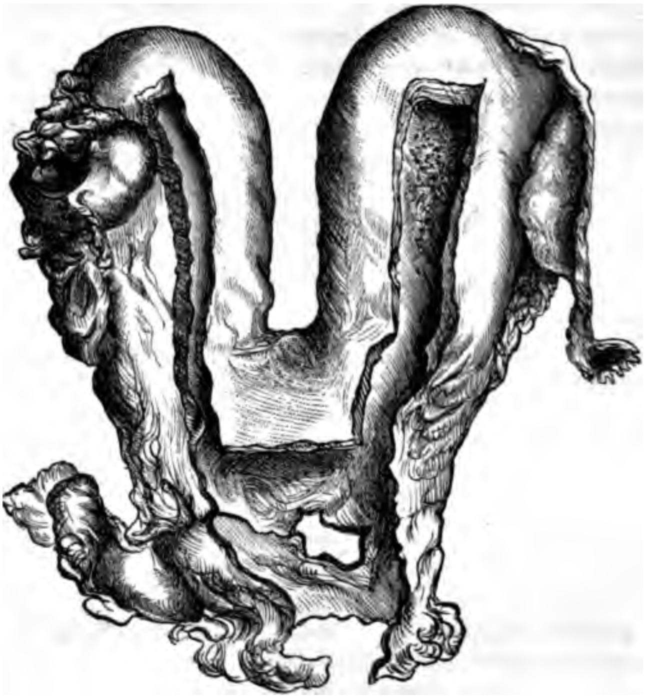


Fig. 676.—Uterus duplex bicornis. The cavities are opened from behind. Fœtation had occurred in the right, but the left had also enlarged. The hæmatocele seen attached to the left may have been from a former fœtation. (From a preparation in Museum of Western Infirmary, Glasgow.)

(*b*) *Uterus duplex bicornis* (also *uterus duplex*).—In this, which is not an uncommon form, there is externally one vagina, which may or may not be divided by a septum, but there are two uteri, which may, however, be united externally in their lower parts. Each uterus has a distinct cervix and os, and each is capable of utero-gestation. Even in cases where the bodies are completely separated (as in Fig. 676) the unimpregnated uterus enlarges with the other.

In the case of which Fig. 676 is an illustration death occurred a fortnight after delivery. Both organs were enlarged and almost equally so, the one which had borne the fœtus measuring 4½ inches from os to fundus and the other 4¼. There had been a previous pregnancy, and this had probably been in the uterus which had not borne the fœtus on this occasion. This was inferred from the fact that this uterus had adhesions around it and a hæmatocele on its posterior wall.

(*c*) *Uterus septus.*—In this the parts appear single externally, but the cavity of the uterus is divided by a septum which may or may not be continued into the vagina.

(*d*) *Uterus bicornis.*—There is one cavity in the lower part of the uterus, but at the fundus the parts diverge. In some cases there is a mere depression in the middle of the fundus, so as to give the organ somewhat of a heart shape, in which case the term *uterus arcuatus* is used, from the bowed or bent character of the outline.

(*e*) *Uterus subseptus* is a form in which the uterus, externally single, is partially divided within by a septum.

Literature.—KUSSMAUL, Mangel, Verkümmerung und Verdoppelung der Gebärmutter, 1859; MAYRHOFER, in Billroth's Handb. der Frauenkrank., vol. i., part 2, 1878-82.

III.—DISPLACEMENTS OF THE UTERUS.

The arrangements by which the uterus is supported are of importance to the understanding of the displacements of the organ. In the virgin the vagina forms a tolerably solid column, on the summit of which the uterus is supported and so prevented from descending. The vagina is also attached, by means of the pelvic fascia, to the bladder in front and the peritoneum behind. The uterus is further supported by its ligaments, and these, especially the round ligament, assist in preventing its descent, although not so directly as the vagina. As ligaments pass off from its lateral aspects, the uterus is kept from inclining to one side or the other. While capable of very limited movement from above downwards and from side to side, the body of the uterus is very movable, within certain limits, from before backwards. When the bladder and rectum are full the uterus will be tolerably erect. When the bladder is empty it will be inclined forward, and a certain amount of anteversion may be regarded as the normal condition with an empty bladder.

1. **Descent and Prolapse of the uterus.**—The position of the uterus is lowered for the most part as a result of the loosening of the attachments of the organ, combined frequently with increased weight from chronic inflammation. The term Descent is applied to a mere lowering of the position of the uterus, while prolapse implies a protrusion into the vagina, it may be as far as the vulva. When the organ presents outside the vulva the name Procidentia is applied. Besides increased weight of the organ itself, a tumour by its weight may assist in dragging it downwards. As pregnancy, with its various circumstances, often

tends to loosen the attachments of the uterus, prolapse is chiefly met with in women who have borne children. The alteration in position may be produced suddenly by increased intra-abdominal pressure, as in raising a heavy weight.

The vagina must be inverted in proportion to the falling-down of the uterus, and in cases where it is completely procident the vagina will form an external covering continuous with the skin around. As the uterus descends it is held more by its posterior than by its anterior attachments, and there is accordingly a certain amount of retroversion along with the prolapse.

The mucous membrane of the uterus is mostly in a state of catarrh in prolapse, with a profuse mucous discharge, and the organ itself is enlarged (see further on). The mucous membrane of the inverted vagina is thickened, and its epithelium, where exposed, acquires characters like those of the epidermis.

2. **Prolapse of the vagina.**—This occurs mostly in consequence of pregnancy, and seems to be caused by the walls remaining hypertrophied when they ought to undergo the regular involution. The thickened and loose vagina is thrown into folds, and these may project outside the vulva. The prolapse is mostly of the anterior wall, and the urinary bladder is not infrequently dragged downwards with it, forming a **Hernia vesicæ** or **Cystocele.** Much less common is protrusion of the rectum or **Rectocele.**

3. **Inversion of the uterus.**—This is of very rare occurrence. The uterus, which is generally somewhat enlarged, is turned inside out, either by its own contraction or by the exercise of traction on its fundus. These conditions are best fulfilled during or after parturition, especially when the umbilical cord is pulled on while the placenta is adherent. It may also occur in connection with a tumour growing inside the uterus and attached to its internal wall. The inverted uterus projects from the vulva as a bleeding mass, the hæmorrhage being frequently so severe as rapidly to cause death. If the patient survive and the organ is not restored, inflammation results, and the uterus acquires attachments in its new situation.

4. **Flexions and Versions of the uterus.**—Flexion is the bending of the uterus on itself, while version is the displacement of the entire organ forwards or backwards.

In **flexions** the bend takes place at a level corresponding with the os internum, so that the cervix is in one plane and the body of the uterus in another. The reason of this is that the uterus is specially fixed at this level by its peritoneal attachments, the body of the uterus being specially movable. Flexions are often the result of adhesions due to perimetritis, these adhesions dragging the organ backwards or forwards, and tending to fix it. Abnormal looseness of the organ, especially after delivery, renders it more liable to bend. When the flexion has become habitual there is apt to be atrophy in the concavity. The flexions are divisible into the two forms—**Anteflexion** and **Retroflexion.**

In **versions** the uterus lies more horizontally than usual, the os projecting in one direction and the fundus in the opposite. They occur from similar causes to those which produce flexions. They are similarly divided into **Anteversions** and **Retroversions.**

These flexions and versions sometimes produce serious results in the uterus itself. It has been mentioned above that, in the concavity of the bend, the uterine tissue frequently wastes and becomes less able to retain the uterus in the upright position. Then the bend, if at all sharp, compresses the vessels, and may lead to a chronic congestion, by and by resulting in hypertrophy. Further, the curve may obstruct the canal of the cervix, thus leading to dysmenorrhœa. The flexions and versions not infrequently predispose to prolapse. Again, the fundus of the uterus projected backwards is apt to irritate the rectum and so induce repeated straining efforts which tend to force the uterus down.

5. **Other displacements.**—The uterus is liable to various other displacements, which, however, mostly stand in a different position to those given above. There is elevation or displacement upwards by the dragging of structures adherent to the organ, or by the pressure from below of tumours or collections of fluid in the pelvis. It is also subject to all sorts of deviations when involved in tumours and inflammations of the pelvic organs.

IV.—THROMBOSIS AND HÆMORRHAGES.

1. **Thrombosis of the uterine veins.**—This is an occasional result of the puerperal state, but sometimes it occurs as a result of tumours of the uterus, and even in affections of the neighbouring parts. The resulting condition is expressed by the clinical term **Phlegmasia dolens.** In the puerperal form the starting-point of the thrombosis is the placental surface of the uterus, and it is most apt to occur when, through imperfect contraction of the uterus, the veins are left with gaping mouths. It may be a question whether the introduction of septic material induces the coagulation, but in the usual absence of the general symptoms of septic poisoning it may be doubted whether this has to do at least with the extension of the coagulation. Starting at the uterus, the thrombosis readily extends to the iliac veins and onwards to the femoral and its branches.

The result is often an extensive thrombosis of the veins of the legs, generally beginning in those of the left side. There is usually a hard brawny œdema of the whole lower extremity.

Thrombosis here, as elsewhere, produces a chronic inflammation in and around the wall of the vein (*Phlebitis* and *Periphlebitis*), so that there is often considerable adhesion of the vein to its sheath and of the sheath to the parts around. The lymphatic vessels may be affected by this adhesion and partially obstructed. In some cases the thrombi become calcified, and **phleboliths** result (see Fig. 382, p. 583).

2. **Hæmorrhages in and around the uterus.**—Hæmorrhage is a normal occurrence in menstruation and parturition, but it may assume pathological characters when in excess or when the blood is unduly retained.

(*a*) **Menorrhagia** is excessive hæmorrhage at a menstrual period. It is induced by various constitutional conditions, but also by local lesions of the uterus, more especially tumours. Tumours of the uterus also frequently induce hæmorrhages apart from the menstrual periods.

(*b*) **Dysmenorrhœa membranacea** is a condition in which membranous structures are evacuated by the uterus along with the blood in menstruation. These sometimes form a complete cast of the interior of the uterus, but more usually they are in smaller pieces. The membrane is variously composed in different cases. Sometimes it is no more than condensed blood-clot or fibrine, perhaps in some cases left over from a previous menstruation. In other cases, however, it is composed of the mucous membrane of the uterus. It is chiefly the superficial layers consisting of epithelium which are exfoliated, but the uterine glands may be present in the membrane, and even the submucous tissue.

This condition is usually regarded as due to an inflammation of the uterine mucous membrane, to which the name *endometritis exfoliativa* has been given, but this view is not universally accepted. There is no doubt some inflammation, as the membrane contains round cells.

(*c*) **Placental polypus of the uterus** is of some importance, as it may resemble a tumour. It consists of a polypoid mass of blood-clot attached to the internal surface of the uterus and hanging into its cavity, or even projecting into the vagina. It is sometimes called the *Fibrinous uterine polypus.* The whole placenta may be retained as in Fig. 677, or it may be only a portion. On the other hand, the rough surface after removal of the placenta may induce coagulation of blood, which if retained may grow by fresh coagulation. The polypus is usually associated with hæmorrhage throughout its course. The blood mostly escapes into the vagina, but some of it may coagulate and increase the size of the polypus.

(*d*) **Pelvic hæmatocele.**—This name expresses an accumulation of blood in the neighbourhood of the uterus. Two forms have been described according as the blood is in the peritoneal cavity or beneath the peritoneum. A convenient nomenclature is to call the intra-peritoneal form Pelvic hæmatocele and the extra-peritoneal form Pelvic hæmatoma.

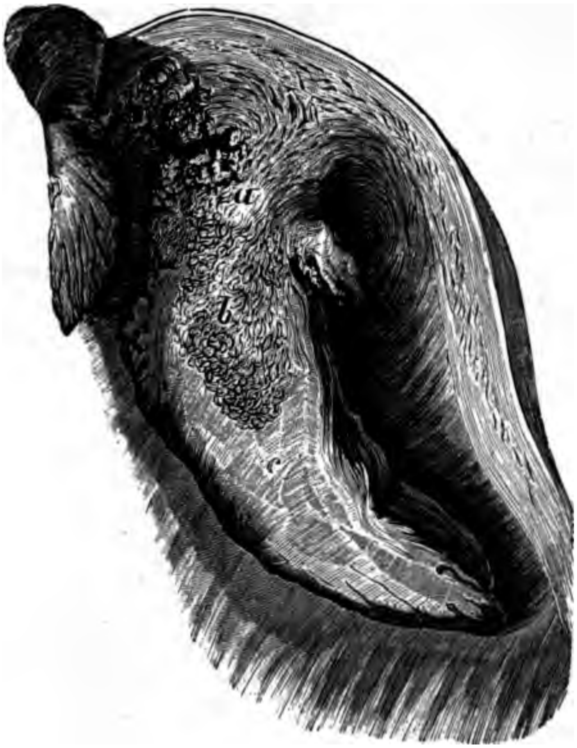


Fig. 677.—Placental polypus of the uterus after an abortion in the second month; *a*, projecting part of maternal placenta and wall of uterus; *b*, remains of fœtal placenta; *c*, stratified coagula around the fœtal placenta. Natural size. (Virchow.)

Intra-peritoneal hæmatocele is much more serious than the other. It arises as a result of any hæmorrhage inside the peritoneum, such as rupture of an ectopic pregnancy, rupture of an aneurysm, regurgitation of the blood during menstruation when there is obstruction to the regular outflow, rupture of enlarged veins, or of the vessels in adhesions around the uterus.

The blood, whatever its source, accumulates chiefly behind the uterus in Douglas's pouch. Acting here as a foreign body it sets up a chronic inflammation with the usual results of new-formation of connective tissue which surrounds and causes partial absorption of the blood. There may be thus considerable perimetritis brought about. In some cases suppuration ensues, and an abscess is formed, chiefly where a fœtus is present from rupture in ectopic pregnancy.

Extra-peritoneal hæmatocele or hæmatoma also originates from rupture of the cyst in ectopic pregnancy, but it occurs also not infrequently as a kind of vicarious menstruation, and may arise in other ways. The blood mostly accumulates in the broad ligament, which it may distend into a bulky tumour. It may also pass around the uterus and rectum, sometimes obstructing the latter. The accumulated blood usually undergoes absorption, but it may leave thickenings and adhesions behind.

Literature.—BERNUTZ, Clin. memoirs on dis. of women (Syd. Soc. transl.), 1866; GUSSEROW, in Volkmann's Sammlung, No. 81; FRIEDLÄNDER, Phys.-anat. Untersuch. über den Uterus, 1870; LEOPOLD, Die Uterusschleimhaut während Menstruation, etc., 1878; BÄNDL, in Billroth's Handb. d. Frauenkrankh., v.; LAWSON TAIT, Ectopic pregnancy and pelvic hæmatocele, 1888; ZIEGLER's Lehrbuch, latest edition.

V.—ATROPHY, HYPERTROPHY, AND DILATATION OF THE UTERUS.

1. **Atrophy.**—The uterus may retain in adult life the undeveloped condition of that of the child. There may be on the other hand, a premature atrophy, in some cases ascribed to long-continued catarrh, frequent pregnancies, pressure of tumours, etc., in which the organ anticipates the normal senile involution.

2. **Hypertrophy.**—This sometimes occurs as a result of imperfect involution after the physiological enlargement of pregnancy, and in this case the increase in size is from excess in the muscular substance mainly. Hypertrophy of a similar kind occurs from the presence of tumours in the wall of the uterus. There may be hypertrophy from congestion and chronic inflammation, however caused.

A special **Hypertrophy of the cervix** has been observed in many cases. It occurs as a result of imperfect involution after pregnancy, but also as a consequence of prolapse of the vagina, the cervix being dragged down and greatly elongated. With very little descent of the uterus the cervix may be so elongated as to present externally.

3. **Dilatation of the cavity.**—This occurs in consequence of the retention and accumulation of material in the uterus. It results, therefore from **Obstruction of the vagina** or of one of the orifices of the uterus. There may be imperforate hymen or congenital closure of

the external or internal os (generally the external). When the period of puberty is reached and menstruation begins, the blood accumulates in the uterus and there may be enormous distension, the contents having a tarry or pulpy character. This condition is designated **Hæmatometra**. The uterus may assume the size of the pregnant organ, and there is thickening of its walls, which, however, are loose. If escape is not provided artificially the uterus may actually rupture; not usually into the peritoneum, but, after the formation of adhesions, into some neighbouring organ. The rupture is by a process of ulceration from within, unless external violence bursts the distended organ.

There may be an acquired **Obstruction of the os uteri** as from chronic catarrh, or even from inflammation occurring after delivery. Cancer, as we shall see, is a common cause. In such cases also we may have a hæmatometra from accumulation of menstrual blood. It is more common, however, to have such closure after menstruation has permanently ceased, and in that case a catarrhal secretion may accumulate and distend the uterus. After a time the contents, which are at first mucous in character, become serous, and the condition called **Hydrometra** is brought about.

Pyometra is the name given to the condition when the fluid is purulent. This is sometimes met with when a cancer obstructs the canal.

The organ is sometimes distended with **Gas**, a condition designated **Physometra**. This may be the result of decomposition of the accumulated fluid in hydrometra, or from decomposition of retained clots, etc.; but cases have occurred in which the cavity has been dilated with gas and assumed considerable proportions without apparent cause.

VI.—INFLAMMATIONS OF THE UTERUS AND ITS APPENDAGES.

These are somewhat various, and they are differently named according to the locality specially affected. We have thus to consider **Endometritis, Metritis, Salpingitis, Perimetritis, Parametritis** and **Oophoritis**. The condition of the uterus and vagina after delivery lays these structures open to the occurrence of septic inflammations, and many of the conditions mentioned have this origin.

1. **Inflammations of the uterus.**—These are divided into inflammations of the mucous membrane and of the muscular substance.

(*a*) **Endometritis.**—This is an inflammation of the mucous lining of the uterus. We may have an **Acute inflammation** set up by the extension of a gonorrhœal inflammation from the vagina, or in consequence of parturition, or in the course of an acute fever. The inflammation may go on to suppuration or even to sloughing of the mucous membrane and the formation of ulcers. Casts of the uterus resembling those met with in membranous dysmenorrhœa are sometimes seen (Fig. 678). It is apt to extend from the uterus to the Fallopian tube, broad ligament, etc. (see further on).

Chronic endometritis or chronic catarrh is a very frequent disease, and, as a whitish discharge is a characteristic feature, the condition is often called **Leucorrhœa**. Apart from the excessive secretion the mucous membrane is apt to become thickened, and it may be thrown into folds or give origin to **Mucous polypi** and **Cysts**. The cervix especially is often thickened, and the os may present ulcerations. During pregnancy inflammations sometimes arise, giving occasion to abortions, adhesions of the placenta, and other lesions. The catarrh may also have its origin in a tumour, a flexion or a version of the uterus.

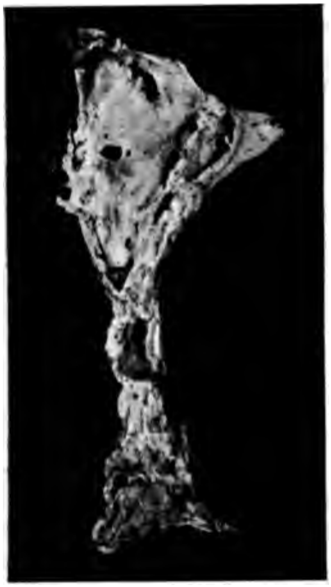


Fig. 678.—Fibrinous cast of uterus.

(*b*) **Metritis.**—This name is given to inflammation of the muscular substance of the uterus. Acute inflammation, even with infiltration of the muscular substance with blood, may follow gonorrhœa.

We have also frequently a **Chronic inflammation** leading to **Induration**, it may be with enlargement of the uterus. This is frequently brought about by **Imperfect involution** of the uterus after parturition, but also results from the various causes which bring about endometritis. The condition consists in a new-formation of connective tissue, and from its correspondence with interstitial inflammation in the liver and elsewhere it is sometimes called **Cirrhosis**, especially when there is great induration.

2. **Inflammations around the uterus.**—The structures in the neighbourhood of the uterus are very frequently the seat of inflammation. This occurs by extension of inflammation from the uterus itself, chiefly in cases of **Gonorrhœal** or **Puerperal endometritis.**

The extension of the inflammation occurs by two different paths. The most frequent is by the Fallopian tubes, producing in the first instance an inflammation of them (*Salpingitis*), and then passing on to the pelvic peritoneum and ovaries, producing a *Perimetritis*. The other mode of extension is to the subperitoneal tissue, and the result is an inflammation in the loose tissue of the pelvis, a *Pelvic cellulitis* or *Parametritis*. It may be said that the one mode of extension usually involves a salpingitis and perimetritis, sometimes with oophoritis, and the other a parametritis.

(*a*) **Salpingitis** is an inflammation of the Fallopian tube, and it varies in character and intensity. There may be a simple catarrh extending from the uterine mucous membrane, or an acute septic or gonorrhœal inflammation.

A frequent result of salpingitis is **Adhesion and Occlusion of the tube**. The fimbriated extremity is frequently attached to the ovary or to a neighbouring peritoneal surface, this attachment being by connective tissue in the usual fashion of inflammations. The tube is also frequently distorted greatly by the adhesions, doubled on itself, or otherwise altered in position. The uterine orifice of the tube is so small that when the fimbriated extremity is occluded the tube is virtually closed, and the inflammation may completely occlude the uterine orifice as well.

In this case the tube frequently becomes **Distended** with various contents, and names are applied according to the different character of the contents. In simple inflammations a watery or serous fluid may collect, the result being a **Hydrosalpinx**. In more acute cases pus distends the tube, **Pyosalpinx**, or blood may be extravasated, **Hæmatosalpinx**. The dilatation of the tubes is sometimes very great, so that a considerable cystic cavity may result.

(*b*) **Pelvic peritonitis or Perimetritis** is an exceedingly frequent lesion. It may follow on salpingitis, but the irritant may reach the peritoneum by the tube without the latter being inflamed. It is probable also that inflammation may extend from the uterine wall to the peritoneum.

The inflammation is usually septic, and is sometimes acute, so as to be suppurative, in which case it may extend to the general peritoneum. But even when acute it may be limited by adhesions, and abscesses may form which remain confined to the pelvis. Such abscesses are sometimes so mixed up with adhesions that it may be difficult to distinguish whether they are in the peritoneum or outside it. They may ultimately burst into the rectum or vagina, or at the cutaneous surface.

Chronic Perimetritis is characterized by the formation of **Adhesions** and membranous new-formations around the uterus. These are most frequent behind the uterus, uniting it to the rectum. The adhesions are frequently drawn out so as to form long attachments between the parts.. Displacements of the uterus and abnormal fixations are frequent results of such adhesions.

The complete picture of perimetritis is that in which the uterus is buried in adhesions which abolish the pouch of Douglas behind, and completely mat together the broad ligament, tube, and ovary, so that the two latter structures are often indistinguishable. The tube may be dilated in the manner mentioned above.

(*c*) **Oophoritis**, or inflammation of the ovary, mostly occurs in connection with perimetritis. **Acute oophoritis** is usually a sequel of the puerperal state. A septic perimetritis accompanied by pelvic abscess may be associated with abscesses in the ovaries. The pus at first forms in elongated streaks from the hilum to the periphery, but after a time there are more distinct abscesses. The Graafian vesicles also frequently become filled with pus. The affected ovary is surrounded by adhesions, and it is frequently difficult to dissect out the organ.

Chronic oophoritis also occurs in connection with perimetritis, but it has sometimes a more independent origin. As the ovary is liable at the menstrual periods to great vascular disturbance, we may have, from checking of menstruation and otherwise, a chronic inflammation set up.

The condition has the characters of interstitial inflammation, and is comparable to cirrhosis of the liver or kidney, being, like these, accompanied by shrinking of the organ. The capsule is thickened, and the contracting tissue in the organ produces irregular depressions of the surface. The thickening is often peculiarly manifest around the Graafian vesicles, and this, with the thickening of the capsule, may prevent the vesicles bursting. Sometimes a ripe vesicle, instead of bursting externally, ruptures into the substance of the ovary, and so produces further inflammatory disturbance. With these changes in the ovary itself there is usually adhesion of the capsule to the parts around, the chronic inflammation causing the formation of vascular connective tissue which unites opposed surfaces. In this way there may be displacements of the ovaries.

If the Graafian vesicles are prevented from bursting, the fluid which naturally exists in them may become augmented, and the vesicles thus be converted into **Cysts** (Fig. 679). A limited number of small cysts may thus be formed, and it is not impossible that cysts having this origin may grow to some size, having always the character of simple cysts with serous contents. It is to be rememberd that in old age the ovaries are often shrunk and the capsule thickened, but this is not to be set down as the result of chronic inflammation.

(*d*) **Pelvic cellulitis or Parametritis.**—This consists in a subacute inflammation of the pelvic connective tissue generally occurring after delivery, but also sometimes as a result of operations on the uterus, the introduction of pessaries or the uterine sound, etc. The inflammation is no doubt septic, being in this respect comparable with erysipelas and phlegmonous inflammations generally. The inflammation extends from the uterus, finding its way apparently by the lymphatic spaces. There are the usual results of inflammation, but the exudation is here the most important. The spaces of the connective tissue become filled up with a seropurulent exudation which may be partly fibrinous. There is in this way a great tumefaction of the subperitoneal tissue, especially of the broad ligament, but also of that in front of and behind the uterus and in the pelvis as a whole. The uterus is thus, as it were, fixed in the midst of tumefied connective tissue, which may be felt as a firm swelling on examination per vaginam.

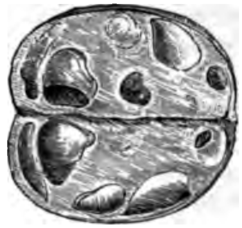


Fig. 679.—Cystic formation in ovary from dilatation of Graafian vesicles. (VIRCHOW.)

Suppuration often ensues, but it may do so very gradually, so that it may be long after parturition before it occurs. The pus sometimes extends a considerable distance from the neighbourhood of the uterus. The inflammation may extend and the suppuration follow into the iliac or even into the lumbar region. The abscesses which result open in very various localities, into the vagina, the rectum, or the bladder, or at the surface in the iliac or inguinal region. In these latter cases the condition may simulate lumbar abscess, and mistake is the more likely as the suppuration has perhaps occurred long after the originating cause. The pus discharged has usually the characters of having been long retained, the corpuscles are largely fatty, and there is usually a fæcal odour due to the proximity of the abscess to the rectum.

Puerperal fever.—This term does not express any single definite morbid condition, but includes cases of septic inflammation connected with the puerperal state, in which acute febrile symptoms occur. The fact that the disease occurs in a quasi-epidemic form and is communicable seems to show that it is due to a specific microbe, but it is probable that any of the more virulent pyogenic micrococci, such as that of erysipelas, may induce it. The course of the septic inflammation and the mode of extension to the general circulation vary, but much that has been stated above in regard to perimetritis and parametritis applies here.

There is, to begin with, an acute septic inflammation of the uterine mucous membrane, usually accompanied by sloughing and suppuration. From this local seat there is an extension, in the manner indicated above, by the Fallopian tubes or by the subperitoneal tissue. In the former case a **General septic peritonitis** results. The septic poison is absorbed, and we have the regular fever of septicæmia. In the other case a **Septic thrombo-phlebitis** may occur, and we have the phenomena of **Pyæmia** with metastatic abscesses, and septicæmia.

Literature.—Bernutz, loc. cit.; Matthews Duncan, Prac. treatise on perimetritis and parametritis, 1868; Virchow, Ges. Abhandl., 1856; Winckel, Dis. of women (transl.), 1887; Bandl, Handb. der Frauenkr., ii., 1886; Heiberg, Die puerperalen und pyæmischen Proc., 1873; Lawson Tait, Brit. Med. Jour., 1887, i., 825; Lewers, Obstet. Trans., xxix., 1887; Polk (also discussion), Amer. Gynec. Trans., xii., 1887; Hennig, Krankh. der Eileiter, 1876; Barbour, Allbutt and Playfair, Syst. of Gynæc., 1896.

VII.—EXTRA-UTERINE OR ECTOPIC PREGNANCY.

By these terms is meant the development of the fertilized ovum in any other situation than the normal one in the uterus.

The causation is somewhat obscure, but if we accept the views of Lawson Tait it usually results from disease of the Fallopian tubes, which by destroying the ciliated epithelium allows the spermatozoa to pass up the tube and impregnate the ovum before it reaches the uterus.

According to this author normal impregnation always occurs in the uterus, as the ciliated epithelium of the tubes prevents the ascent of the spermatozoa. If the ciliated epithelium be destroyed the spermatozoa may pass up as far as the ovary.

According to the position in which the impregnated ovum settles various forms have been distinguished, namely, **Tubal**, **Tubo-ovarian**, **Ovarian**, and **Abdominal**. The existence of an abdominal pregnancy, except by rupture of a tubal one, is denied by some authorities (Mayrhofer, Lawson Tait), and even ovarian pregnancy is very rare. Undoubtedly tubal pregnancy is by far the commonest. An excessively rare ectopic pregnancy is that in which, from existing perforation of the uterus (as from a previous Cæsarian section), the ovum has escaped into the abdominal cavity.

Tubal pregnancy occurs either in the free part of the tube or in the part surrounded by the uterine tissue. In the latter case the form is called **Interstitial pregnancy**.

If an impregnated ovum settle in the tube, the placenta, as it forms, adheres to the wall of the tube and forms vascular connections. As the tube does not, like the uterus, enlarge under the stimulus of pregnancy, the growing ovum thins its wall, and rupture may occur (*primary rupture*). This often takes place before the fourteenth week. The rupture may be into the peritoneal cavity or into the broad ligament. At the time of rupture there is hæmorrhage, which in the case of rupture into the peritoneum is usually fatal. The ovum may be discharged through the ostium (**Tubal abortion**). The abortion may be complete and be attended with slight hæmorrhage, or it may be incomplete and give rise to excessive hæmorrhage.

As a result of this primary rupture the fœtus usually dies, and in that case the conditions are those of **Pelvic hæmatocele**, intra-peritoneal or extra-peritoneal. In either case there may be subsequent encapsuling or absorption of the dead fœtus (which will be very small) or there may ensue a suppuration of the hæmatocele. Pelvic hæmatocele, as has been mentioned above, is also a common result of incomplete tubal abortion.

The fœtus may survive and the placenta may acquire fresh connections, so as to allow of the completion of the full term of utero-gestation. Before this occurs, however, especially when the fœtus is in the broad ligament, there may be a *secondary rupture*, resulting in some cases in a fatal hæmorrhage, but in others merely in a fresh adhesion inside the peritoneum.

If the full term be reached the fœtus dies, and, unless removed by operation, remains as a foreign body. As a rule general peritonitis results, sometimes with the ultimate formation of an abscess. If the death of the mother does not occur soon the abscess may come to the surface and the fœtus may be discharged piece-meal.

In some rare cases the fœtus gives rise to no active inflammation, and after its death remains quiescent. The fœtus, then, in time acquires the characters which have given rise to the designation **Lithopædion**. It becomes surrounded by a connective-tissue capsule, inside which the mummified fœtus may remain for many years. The capsule usually becomes infiltrated with lime salts, so that a kind of shell is formed around the fœtus. The fœtus itself may be partly calcified, but its soft structures are often little altered or may be converted into adipocere. Cases are on record of a duration of life extending as long as fifty years after an ectopic pregnancy, and in some cases normal pregnancies have occurred in the interval.

Cases have been observed of molar extra-uterine pregnancy.

Literature.—Mayrhofer, Billroth's Handb. d. Frauenkrankh., i.; Lawson Tait, Ectopic pregnancy, 1888 (gives full account and collection of cases of Lithopædion); Virchow, Würzb. Verhandl., i.; Sappey, Comptes Rendus, Aug. 27, 1883; Webster, Ectopic pregnancy, 1895; Ziegler's Lehrbuch (references), latest edition.

VIII.—SYPHILIS AND TUBERCULOSIS.

Syphilis manifests itself in the vagina and vulva in the form of the hard chancre, which may even occur at the os uteri. It does not present in these situations any peculiarities distinguishing it from chancre, as already described. Condylomata of considerable size also occur in the vulva and vagina, often forming warty projections.

Tuberculosis of the tubes and uterus.—This commonly begins in the Fallopian tubes. As the fimbriated extremities open into the peritoneum they absorb any such virus as that of tuberculosis which may be present. Hence it is a regular result of tubercular peritonitis in the female, and also sometimes occurs in tubercular ulceration of the intestine. It is stated by Schramm that it is met with in three per cent. of all females dying of tubercular disease. It is not at all uncommon in tubercular children (see Fig. 680).

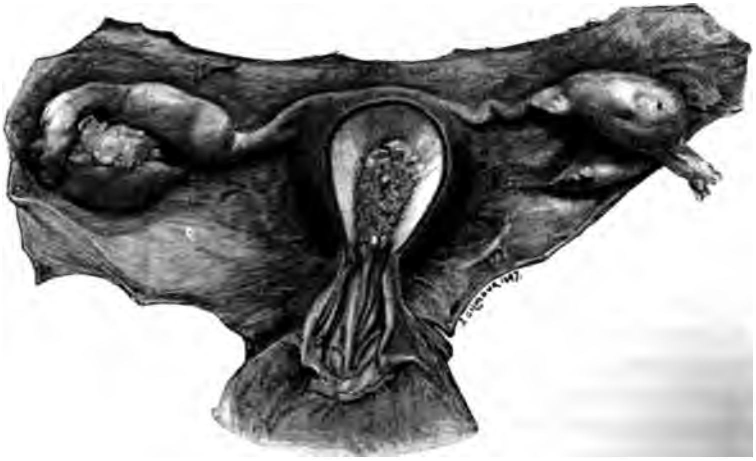


Fig. 680.—Tuberculosis of the uterus and Fallopian tubes in a child.

Tuberculosis of the Fallopian tubes begins at the distal end, and this part is generally found most affected. The mucous membrane is destroyed and replaced by caseous matter which accumulates in the calibre of the tube. The wall is also thickened and infiltrated with the tubercular new-formation. These two conditions lead to a great distension of the tube (Fig. 681) so as to resemble some of the conditions resulting from salpingitis. The condition is sometimes called **Tubercular salpingitis.** This condition is probably of great frequency, and we believe, from observation, that a large proportion of cases which are simply designated salpingitis really belong to the tubercular form. There is not generally much adhesion to parts around, but there may be, especially when the condition coincides with tuberculosis of the peritoneum. In rare cases evidences of spontaneous healing are seen (Fig. 682).

The tuberculosis frequently extends to the **Uterus**, where ulcers form, and there may be extensive destruction of the mucous membrane.

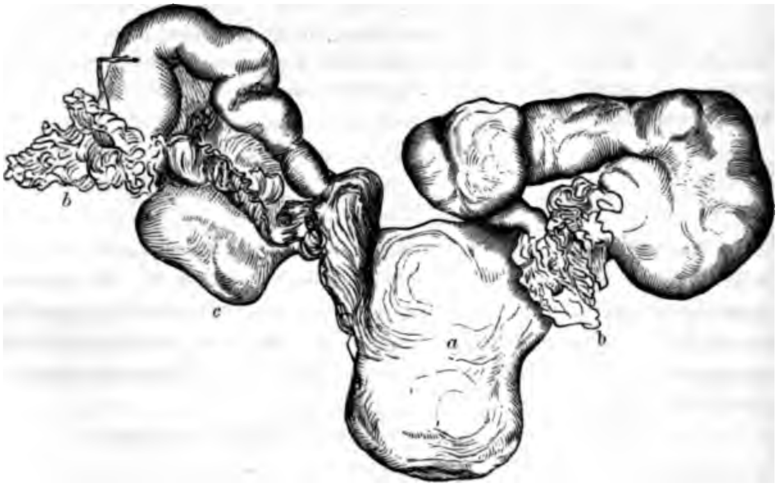


Fig. 681.—Tuberculosis of the Fallopian tubes seen from behind. *a*, uterus ; *b*, *b*, fimbriated extremities of the tubes ; *c*, left ovary. The right tube is seen to be very greatly dilated and convoluted. The dilatation disappears just before the uterine termination of the tube. The left tube is much less affected, being most dilated at its distal part. There was also tuberculosis of the lungs and mesenteric glands.

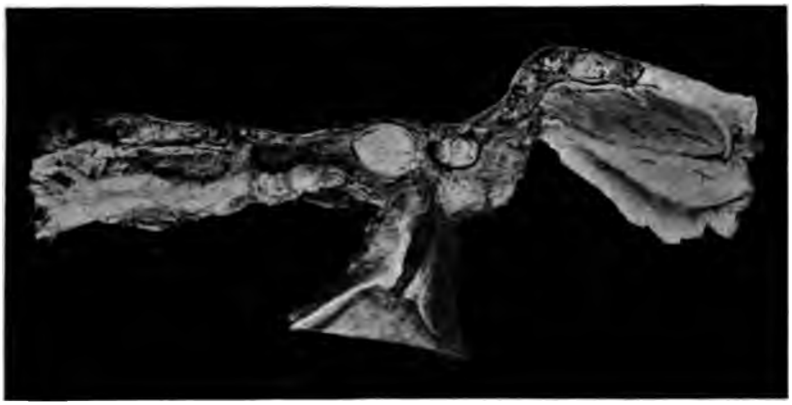


Fig. 682.—Healed tuberculosis of the Fallopian tubes and uterus. The tubes are filled with caseous and cretaceous masses. The cavity of the uterus is in great part obliterated, and at its upper part contains caseous nodules.

The whole internal surface is sometimes involved. In rare cases the **Cervix uteri** is affected. Occasionally also the **Vagina** is involved.

Tuberculosis of the **Ovaries** is exceedingly rare. It occurs in the form of caseous masses.

Literature.—Mosler, Tuberkulose der weibl. Geschlechtsorgane, 1883; Schramm, Arch. f. Gynäcol., xix.; Steven, Glas. Med. Jour., xix., 1883; Williams, Johns Hopkins Hosp. Reports, iii., Nos. 1, 2, 3, 1892; Cullen, ibid., iv., 1895; Pozzi, Treatise on gynæcology, iii., Syd. Soc. Trans., 1893; Voigt, Genitaltuberkulose, Inaug. Diss., Kiel, 1896; Meyer, ditto, Inaug. Diss., München, 1896; Fraenkel, Münch. med. Wochen., 1896; Hofbauer, Arch. f. gynäkol., 56, 1898; Davidsohn (Vulva and Vagina), Berl. klin. Woch., 1899; Dürck u. Oberndorfer, Lubarsch and Ostertag, Ergebnisse, vi., 1901.

IX.—TUMOURS OF THE UTERUS AND VAGINA.

1. **Mucous polypi and Adenomata of the Uterus.**—These are met with mainly as the result of chronic inflammation of the mucous membrane, and may spring from the body of the uterus or from the cervix. Sometimes there is a general irregular prominence from hypertrophy of the mucous membrane, but usually there are definite polypoid outgrowths.

The mucous polypus may consist of a limited hypertrophy of the mucous membrane, the tumour being a tolerably firm one unless, as sometimes happens, it becomes soft by œdema or by the excessive development of its vessels. In this latter case we may have a tumour approaching to cavernous in character. On the other hand, polypi may consist largely of **Glandular** structures, new-formed mucous gland-tissue constituting apparently the tissue of the tumour. These polypi are comparatively soft, and may grow to a considerable size, especially when they become **Cystic.** We have already seen that tumours consisting of glandular tissue are peculiarly apt to become cystic, and these form no exceptions. The larger polypi may somewhat distend the uterus.

2. **Myoma.**—The myoma is very infrequent in the vagina and in the cervix of the uterus, but is extremely frequent in the body of the uterus. It occurs in from 10 to 20 per cent. of women beyond 30 years of age, and in about 40 per cent. of those above 50.

The myoma presents great varieties in size, in number, and in the details of its structure. There may be a single small tumour about the size of a pea, or a large growth weighing more than fifty pounds. There are frequently several tumours present, and there may be fifty attached to the same uterus. The tumour is usually hard and on section fibrous in appearance.

In structure the chief variations are in regard to the proportion of muscle, connective tissue, and vessels. The muscle is in bundles which to the naked eye often give a concentric arrangement to the cut surface (see Fig. 685, p. 1159). There is under the microscope, the usual arrangement of the nuclei in the muscular bundles, as shown in Fig. 128, p. 300. The character of these nuclei and their arrangement are sufficiently distinctive of the tumour.

Connective tissue is present between the muscular bundles; sometimes it is dense and, by rendering the tumour compact, gives it a very hard fibrous character. In some cases the connective tissue increases out of proportion to the muscle and a process of induration akin to cirrhosis occurs.

The vessels are usually rather sparse in the myoma, but sometimes great dilatation of the blood-vessels occurs, so as to give a cavernous character to parts of the tumour, a condition indicated by the name **Myoma telangiectodes.** In other cases there is a dilatation of the lymphatic vessels, leading to a condition called **Myoma lymphangiectodes.**

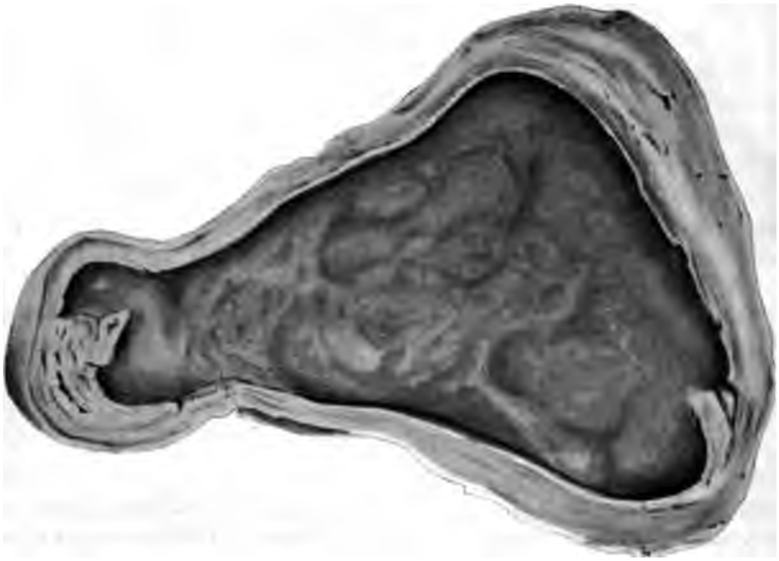


Fig. 683.—Cystic myoma of the broad ligament.

Secondary changes are very liable to occur in the myomas, especially as the tumours frequently grow to large dimensions and are liable to changes in position which interfere with the blood-vessels.

Cysts not infrequently form in them. These are sometimes from dilated lymphatics, but more frequently from softening of the tumour tissue (Fig. 683). Large cysts are thus formed in the midst of large myomas, and may even give rise to a feeling of fluctuation.

Œdema and Hæmorrhage are not uncommon, the latter especially, and more particularly in the tumours with dilated blood-vessels. **Suppuration** also sometimes occurs.

Calcareous infiltration occurs in two different forms. A part of a large tumour may, from obstruction of vessels, be cut off from its blood supply and become obsolete, or a tumour may be separated as a whole and become calcified. In the latter case lime salts may infiltrate it and they are deposited in all the constituents, the muscle-cells, walls of the blood-vessels, and connective tissue (see Fig. 228, p. 407, which is from the calcified part of a myoma).

Separation and Transplantation are not uncommon in the myoma. The subserous myoma, after becoming pedunculated, may acquire vascular connections with the omentum or other part of the peritoneum and ultimately become detached from the uterus. In a case observed by the author a tumour seven inches in length was attached to a very long great omentum and was movable in the abdomen.

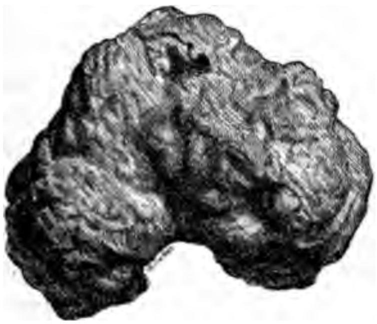


Fig. 684.—Calcified myoma of uterus found lying in the cavity. Half the natural size.

The submucous forms also sometimes become detached, and may be found in the cavity of the uterus; they may either be discharged or retained.

The detached or transplanted myoma is apt to undergo calcification.

In a specimen sent to the author by Dr. Chapman, of Hereford, and depicted in Fig. 684, a myoma was found lying loose in the uterus. It had externally a firm shell which had to be sawn through in order to divide the tumour. The calcification extended to intersecting trabeculæ, which divided the tissue into loculi. In these loculi soft tissue existed which had the microscopic characters of that of the ordinary myoma. The specimen is preserved in the Museum of the Western Infirmary, Glasgow.

The myoma originates in the muscular substance of the uterus, and it may remain in the wall or become displaced outwards or inwards. Hence there are three varieties.

(*a*) **The subserous myoma,** originating in the external layers of the uterus, passes outwards as it grows, and pushes the peritoneal coat before it. In this way it frequently becomes **pedunculated.** The subserous form is often multiple, and as, from its situation, it is protected, the tumour may grow for many years undisturbed, and reach very large dimensions. Such large myomas may be mistaken for ovarian tumours and excised as such, and this is the more likely as cysts not infrequently occur in them.

(*b*) **The Interstitial or Intraparietal myoma** in its growth involves the wall of the uterus, and may cause enormous enlargement of the organ (see Fig. 685; the actual tumour measured 9½ inches in long diameter). This form develops mostly at the fundus, and usually occupies the posterior wall. The tumour and greatly enlarged uterus may form together a very bulky mass, which as a whole is liable to be mistaken for an ovarian or other tumour. The author has met with several cases in which the tumour and uterus were excised under this belief. In one of these the tumours seemed to be multiple and the uterine wall could not be distinguished from the tumours, the greatly enlarged cavity of the uterus being surrounded by irregularly lobulated masses of muscular tissue. In this case it looked as if the uterus as a whole had undergone an irregular hypertrophy, or had grown into a massive tumour.

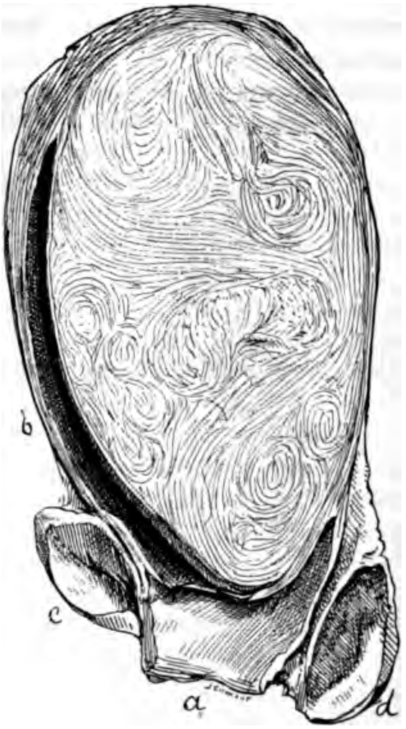


Fig. 685.—Gigantic intraparietal myoma of uterus. It occupied the posterior wall and somewhat distended the os uteri, whose lips were almost of papery thickness. It partly projected into the vagina (*a*). The greatly dilated cavity of uterus (*b*) lay in front. *c*, urinary bladder; *d*, rectum.

(*c*) **The submucous myoma** is the form which most frequently comes under the notice of the practitioner. Arising in the wall of the uterus, it passes inwards, pushing the mucous membrane before it, and from the action of gravity it tends to become **pendulous.** The submucous myoma, therefore, very often presents itself as a polypus (the so-called *Fibroid polypus*), and it may have a very narrow neck. It very often arises at the fundus, and may grow to such dimensions as to fill the uterus, and hang down through the cervix into the vagina (see Fig. 686). The mucous membrane covering the tumour is subject to irritation, and there is frequently **Hæmorrhage and Ulceration,** even with sloughing in some cases.

3. Cancers of the uterus and vagina.—In the great majority of cases the cancer begins just about the junction of the uterus and vagina, and involves both as it extends. The disease is not very common before the age of thirty, and is most prevalent between forty and fifty. It appears also from the statistics of West that, contrary to what is sometimes stated, it occurs much more frequently in women who have borne children than in those who have not, and most frequently in those who have had more than the usual number of pregnancies; it is as if the disease developed most readily when the uterus is deteriorated by repeated conceptions.

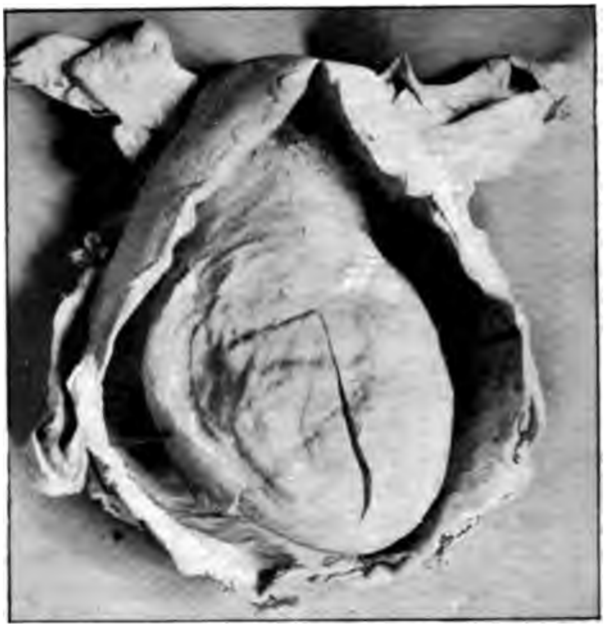


Fig. 686.—Large submucous myoma attached near the fundus and distending uterus and vagina.

The cancer mostly consists of large flat epithelial cells, and in most cases these insinuate themselves amongst the constituents of the uterine wall, while in some cases the growth is more superficial. Hence it is possible to distinguish an infiltrating from a superficial form, the latter being frequently designated Epithelioma.

Infiltrating cancer begins as an infiltration of a limited part of the portio vaginalis, and extends more or less round the external os. By and by the whole portio vaginalis is converted into a hard, irregularly prominent tumour. At first the infiltration is confined to the mucous membrane and submucous tissue, but by degrees it spreads both deeply and laterally. It insinuates itself into the muscular substance of the uterus, separating and breaking up the muscular trabeculæ, which come to form a kind of rough stroma for it (see Fig. 687). It also passes into the vagina, infiltrating its wall. Very soon ulceration of the surface sets in, and in its subsequent course there is a progressive ulceration and infiltration, the former following the latter. The infiltration passes into the body of the uterus, but does not usually reach the fundus before the death of the patient. If the parts be examined post mortem (Fig. 688), it will be seen that an irregularly excavated ulcer occupies the adjacent parts of the uterus and vagina, rendering their respective limits inappreciable. Then, outside this, there is the whitish cancerous tissue, which extends into the uterine substance some lines beyond the ulcer.

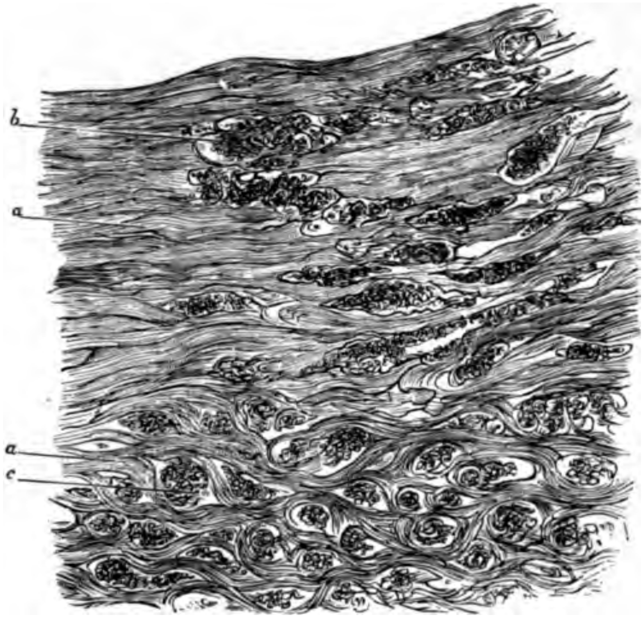


Fig. 687.—Section of cancer of uterus under a very low power, showing mode of advance into wall of uterus. *a*, muscular substance of uterus, interrupted frequently, (as at *b*) by masses of cancerous structure. At lower part of figure (at *c*) the muscular substance is still more frequently interrupted and the tissue has quite an alveolar appearance, the muscle partly forming the stroma. × 22.

This disease affects neighbouring structures. There are cancerous masses usually in the ligaments and under the peritoneum. The bladder is frequently adherent to the uterine cancer and its mucous membrane is red and irregular, or else it presents cancerous nodules. The ulceration even extends sometimes into the bladder, which forms thus a communication with the vagina. The rectum is much less closely related to the cervix uteri than is the bladder, and it is less frequently involved. Those parts of the uterus which are not involved by the cancerous process are inflamed, and adhesions are formed to the rectum and urinary bladder.

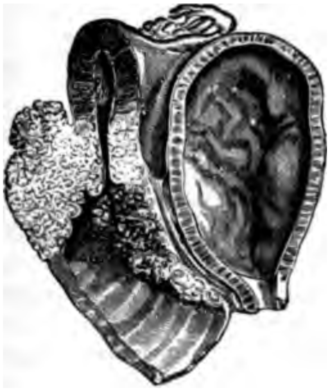


Fig. 688.—Cancer of uterus, the parts shown in section. To the right is the urinary bladder. To the left are vagina and uterus, both of them to a large extent converted into irregular cancerous masses. (GRAILY HEWITT from MARTIN.)

It sometimes happens that the new-formation of cancerous tissue is more vigorous than the ulceration, and in that case we may have prominent ragged masses hanging into the vagina.

The microscopic examination of this form of cancer shows masses of epithelial cells, usually of considerable size, arranged irregularly in the alveoli, the stroma being largely formed by the remains of the structures into which it has infiltrated.

Epithelial cancer (*Cancroid*) is hardly to be distinctly delimited from the former, but is characterized by a more superficial outgrowth of prominent warty projections, while the deeper infiltration is slower and less in degree. The disease begins, as in the other case, in the portio vaginalis, and at first there is little more than a prominent warty outgrowth. But the warty growth increases while the base becomes infiltrated till a bulky prominence results, whose surface, consisting of masses of papilliform projections, gives the character of the **Cauliflower excrescence** (Fig. 689).

This form of tumour is also liable to ulceration, and there may be a combination of ulceration with papilliform projections, although, after a time, the papillæ may be destroyed and the appearances approximate to those of the other form of cancer.

Under the microscope the structure here is more that of flat-celled epithelioma. The prominent papillæ are covered with pavement epithelium, and the deeper infiltration consists of masses of flat cells.

A few cases have been observed in which **Colloid cancer** has been the form occurring in the uterus, the situation being the same as in the other more common forms. In many cases also a cancer may arise from the fundus uteri.

4. **Sarcoma of the uterus and vagina.**—This form of tumour is very rare. It originates mostly in the substance of the uterus, and may form an extensive infiltration or a limited tumour. The commonest form is the spindle-celled sarcoma, but the round-celled form also occurs. Sometimes, but very rarely, a myoma assumes the characters of a sarcoma, becoming soft and loose in its structure, and its cells more detached from each other. We thus have a **Myosarcoma.**

Deciduoma malignum is considered further on.

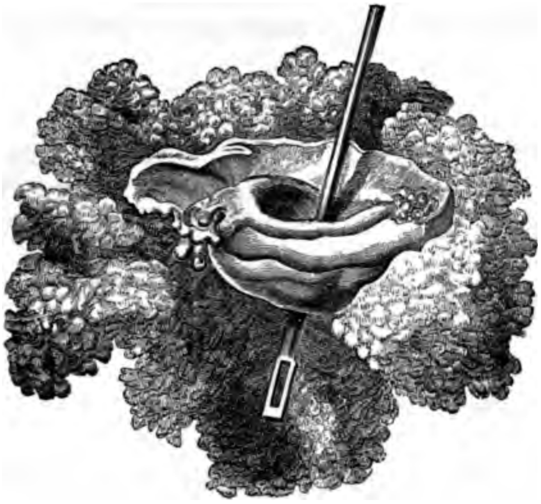


Fig. 689.—Cauliflower cancer of posterior lip of os uteri. A probe is passed through the os, and the anterior lip in front of it is seen to be normal, while a cauliflower growth projects from the posterior. (Simpson.)

Parasites are rare in the uterus and vagina. Thread worms may pass over from the rectum. Bacteria are met with in the vaginal secretion, the leptothrix being frequent. In gonorrhœa the gonococcus is present. The öidium albicans is found in connection with thrush. The cysticercus cellulosæ has been doubtfully seen in the uterus, and the echinococcus with exceeding rarity.

Literature.—*Myoma*—Virchow, Geschwülste, iii.; Leopold (M. telangiectodes), Arch. der Heilk., 1873; Winckel, in Volkmann's Samml., No. 98; Cullen, Johns Hopkins Hosp. Rep., vi., 1897; see also Literature, p. 329. *Cancer*—Ruge u. Veit, Der Krebs der Gebärmutter, 1881; Williams, Canc. of uterus, 1888; Cullen, Carcinoma of uterus, 1900. *Sarcoma*—Winckel, Dis. of women (transl.), 1887; Beermann, Ueber Sarkoma uteri, 1876; v. Kahlden, Das Sarkom des Uterus, Ziegler's Beiträge, B. xiv., p. 174, 1893; Gläser, Virch. Arch., cliv., 1898; Dobbertin, Ziegler's Beiträge, xxviii., 1900.

X.—TUMOURS OF THE OVARY, PAROVARIUM AND BROAD LIGAMENT.

Introduction.—The ovary and broad ligament are very frequently the seats of cystic tumours, which sometimes attain vast dimensions. The origin and mutual relations of the various forms are not completely disentangled, but a knowledge of the anatomical conditions is necessary as a preliminary.

The ovary lies at the back of the broad ligament. It is free on its two flatter surfaces and along its convex posterior border, but is attached to the broad ligament by its anterior border, which presents a deep groove or *hilum* by which the vessels enter. The ovary is attached to the uterus by a dense **Ligament** (see Fig. 690) and to the Fallopian tube by the **Ovarian fimbria** of that tube (see figure). It will thus be seen, as shown in the figure, that the ovarian ligament, ovary, and ovarian fimbria, as it were, circumscribe a portion of the broad ligament, which is bounded above by the Fallopian tube. This part, which is called the **Ala vespertilionis** or the bat's wing, is of consequence as it contains the parovarium and also because it frequently comes into evidence in ovarian tumours.

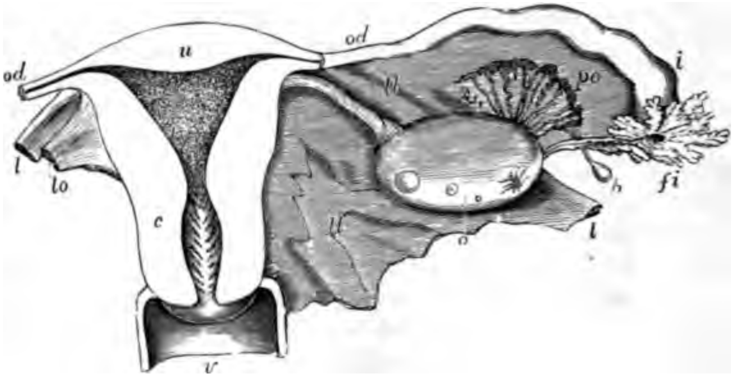


Fig. 690.—Diagramatic view of uterus and appendages. *po*, parovarium; *od*, Fallopian tube; *fi*, its fimbriated extremity; *o*, ovary, with the ovarium fimbria to the right proceeding to the fimbriated extremity, and a ligament to the left attaching it to the uterus near the origin of the Fallopian tube. (QUAIN.)

The parovarium, which is the remains of the Wolffian body, is usually easily made out. It lies between the two folds of peritoneum in the ala vespertilionis. It is readily seen in most normal subjects by holding the parts up against the light. It then appears, as in Fig. 690, *po*, that the organ is composed of a transverse tube or duct, and of a number of vertical tubes, 8 or 10 of which are usually well developed. **The transverse tube** is the duct of Gärtner, and it has been traced inwards to the wall of the uterus and onwards to end in the vagina close to the urethral wall. This tube frequently ends distally in a small pedunculated cyst (*h* in figure). **The vertical tubes** of the parovarium pass towards the hilum of the ovary, and they partly enter into the formation of the ovary, so that some authors describe a medullary part of this organ next the hilum and containing these Wolffian structures, and a peripheral or cortical portion containing the ova.

It follows from these anatomical relations that a tumour of the ovary proper will generally grow into the peritoneum, hanging free with a narrow pedicle. On the other hand, one arising in the parovarium or in the substance of the broad ligament, being subperitoneal in its origin, will expand the broad ligament and be seldom pedunculated.

1. **Simple cysts of the ovary** occur which are in many respects comparable with the simple cysts which are so frequent in the kidney, and like them have no very special significance (see Kidney). They are produced by **Dropsy of the Graafian vesicles**, as was proved by the discovery by Rokitansky of an ovum in such a cyst. Simple cysts may be of congenital origin, having been observed in new-born children.

As a general rule there are several cysts simultaneously developed, usually from ten to twenty, but one or a few only may attain a preponderating size. The cysts have a distinct smooth lining membrane, with a single layer of epithelium. The contents are mostly clear serum, but they may be dark from hæmorrhage or turbid from inflammation. The enlargement of the ovary is not generally great in this form of cystic disease; it rarely reaches the size of the fist, and still more rarely that of the head. If there are several cysts, they take shape by mutual pressure.

2. **Colloid ovarian cystoma.**—This form is of much more frequent occurrence and vastly more important. To this class of cysts the name **Cystoma** is properly applied, because they arise by a distinct new-formation, there being first produced a preparatory tissue, which goes on to the formation of the cysts. The preparatory tissue is glandular in character, and hence the names **Adenoma** and **Adenocystoma** are sometimes applied. This group includes the characteristic **Multilocular cysts** of the ovary.

These cysts form bulky tumours, and while the tumour itself is formed of a number of larger and smaller cysts, there is nearly always, in the walls of these, more or less solid material which shows various stages in the process of cystic formation. The tumour, sometimes of enormous size, represents the **Ovary as a whole**, and is not merely something added to it, the external covering of the cyst corresponding strictly with the surface of the ovary.

The solid tissue in the wall of the cysts shows the various stages in the process of development. It shows, microscopically, a glandular structure (see Fig. 691) in the form of tubular canals lined with cylindrical epithelium. These gland-like structures often project into cysts, and altogether they show a very striking power of new-formation. The transformation of the gland-like tissue into cysts is readily seen in many cases. The cylindrical epithelium presents very markedly the goblet form seen in mucous glands (Fig. 692), and it secretes a mucous or colloid material, which accumulates in the cavity and distends it more and more into a globular cyst. We have therefore, in

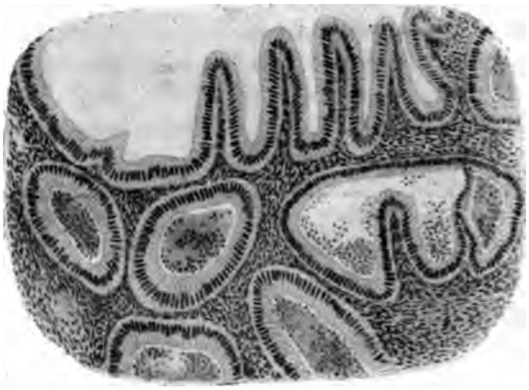


Fig. 691.—From a colloid ovarian cystoma. Gland-like tissue and the beginning of cysts. × 70.

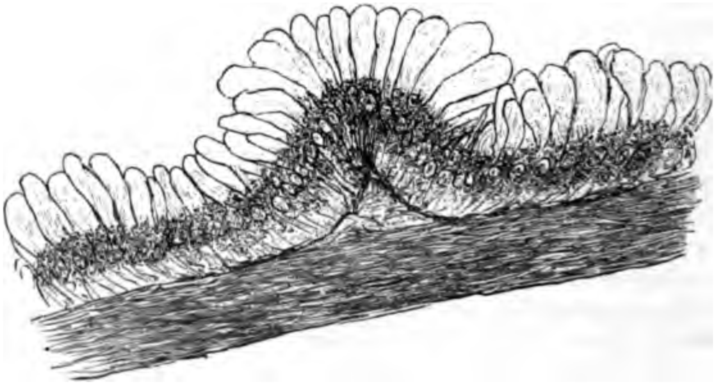


Fig. 692.—Portion of wall of colloid ovarian cyst. The lining epithelium is mostly in the form of goblet cells. × 350.

the walls of the cysts, very commonly large numbers of smaller cysts which take their shape by mutual pressure. Cysts formed in this way project into the already existing cysts as they grow, and may afterwards burst and become flattened out on the wall of the older cyst. As all the cysts have had a similar origin, they are lined with epithelium, whose function it is to secrete a colloid or mucoid fluid, and so the cysts, once formed, have an almost continuous tendency to increase.

As regards the **Origin and Significance of the glandular tissue,** authors are generally agreed that, as we have here essentially to do with glandular epithelium, its origin is to be referred to the primordial epithelial structures of the ovary. The primordial ovary consists of a layer of epithelium on the surface of the connective-tissue projection. The ova form by the penetration inwards or reduplication of this superficial epithelium, which at first forms a series of communicating channels or follicles which Waldeyer compares to a cavernous tissue. By the constriction of these canals the ova are formed, it being doubtful whether the cells of the membrana granulosa which lines the Graafian vesicle are derived from this epithelium or from the connective-tissue stroma. The glandular formation in ovarian cystoma may be regarded as a pathological and exaggerated recurrence of the fœtal condition.

The **Naked-eye appearances** of the colloid cystoma are generally quite characteristic, and may be inferred from Fig. 693, in which a tumour is shown in section after hardening. The tumour represents an ovary, and its outer covering is the outer covering of the ovary with its layer of endothelium. The surface is usually smooth and very often free from adhesion to neighbouring structures. In shape the tumour is generally more or less globular, but not infrequently it is lobulated on the surface and evidently composed of several cysts. Although the cyst is for the most part obviously multilocular, yet one of the cysts sometimes attains such a preponderating size that the tumour is apparently unilocular. In these cases examination will show the existence of other cysts flattened out in the wall, or collected here and there in clusters. Towards the base of the tumour, but also in many cases at various places, there are solid or semi-solid masses in which cysts are in process of development in the way already described. The size of the tumour is frequently very great. On cutting into it there escapes from the cysts a sticky brownish or yellowish fluid, which is tolerably clear unless some of the secondary changes to be presently described have occurred in it. If, as is usually the case, there are many cysts, they take shape by mutual pressure against each other, while the general globular outline of the tumour as a whole is preserved.

As the ovary hangs free in the peritoneum the tumour also generally expands outwards freely, and preserves a comparatively narrow attachment, called **the Pedicle.** In ovarian cysts as excised the ala vespertilionis will generally be found attached and nearly normal, and the parovarium is often unusually well preserved. The expansion of the tumour is very rarely upwards from the ovary into the ala vespertilionis. If it be so, then the tumour is more sessile and the Fallopian tube may be stretched over its summit.

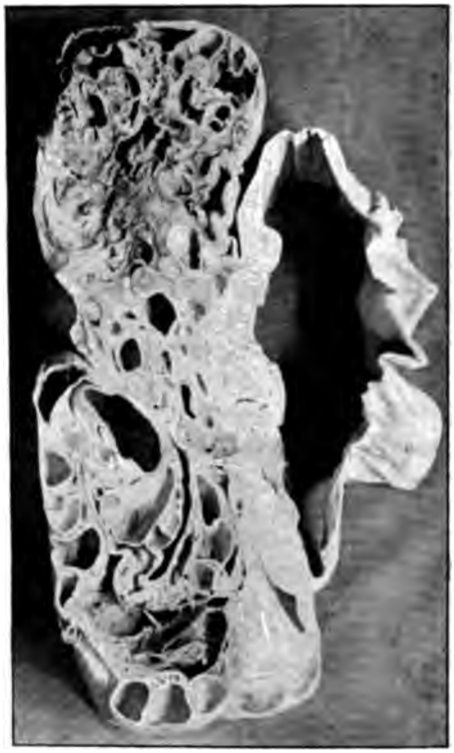


Fig. 603.—Colloid ovarian cystoma in section after hardening. There is one large cyst to the right which has become shrunk. The rest of the tumour consists of cysts of various sizes, with some solid tissue. (About one-third the natural size.)

Secondary changes occur which concern chiefly the contents of the cysts. It seems almost a normal condition in large cysts that the internal wall should present collections of cells in a state of **Fatty degeneration,** these cells being often in many layers. Cells also pass into the fluid, so that in all ovarian fluids cells are to be found of round shape and with oil drops in them. Many of these cells are doubtless leucocytes which have emigrated into the cysts. The number of these fatty cells may be greatly increased, and, as many of them in that case break down, we may have a fluid which is turbid from the presence of numerous fatty cells and free oil. The fluid is also pale like a **fatty emulsion**, and in many cases it resembles pus in its naked-eye appearance. This change is most likely to occur in old and large cysts, but it is not infrequent in younger and smaller ones.

The free fat, if long retained, forms **Crystals of cholestearine**, and in fact these crystals are frequently found in the fluid of cysts which otherwise are not strikingly altered.

Hæmorrhage occasionally occurs into the cysts, and this will cause the fluid to be turbid and deep brown or red in colour. There may also be masses of softened fibrine in the cavity. Sometimes, however, the fluid has a dark brown colour without hæmorrhage.

Inflammation of the cyst-wall is not of very frequent occurrence. There may be an acute suppurative inflammation, so that the contents become mixed with pus and assume more and more of the purulent character. With this there is generally an acute inflammation of the surface, with fibrinous exudation and adhesion to neighbouring structures. If the suppuration continues there is apt to be perforation of the pus into the abdominal cavity with resulting fatal peritonitis. A chronic inflammation is more common, causing adhesion of the cyst to neighbouring parts, and these adhesions may be very extensive and firm.

Perforation or Rupture of the individual cysts which compose the tumour is not infrequent. It has been already stated that coalescence of cysts by rupture of their adjacent walls is a regular process in the course of growth. A rupture externally is much less frequent. It occurs by mechanical violence, by necrosis of parts of the wall from interference with the circulation, from inflammation, or from penetration of the wall by the growth of the secondary cysts.

The rupture occurs usually into the peritoneum, but it may be into the rectum or bladder, inflammatory adhesions having previously formed. According to Bland Sutton a cystoma may rupture and continue to secrete colloid matter which passes into the peritoneum, and may collect there in large quantity. The colloid matter in the peritoneal cavity sets up inflammation which may be somewhat acute. If it lasts for some time there is great thickening, especially of the omentum, which contains colloid masses, and looks like a mass of boiled sago (Doran and Olshausen).

3. **Papillomatous cysts of the ovary.**—Cysts of this kind are regarded by Doran and others as originating in the hilum of the ovary, and

therefore as springing from the remains of the Wolffian body. They form large unilocular tumours with glairy colloid contents like those already described. Instead of a glandular tissue in their walls from which the cysts form, there is a papillary growth into the cavities of the cysts. The intra-cystic growth consists of dendritic papillæ covered with cylindrical epithelium which does not take the goblet characters.

This form of cystoma is sometimes combined with the other, as if the new-formation had originated from both parts of the ovary.

The papillomatous cyst has much **more malignant characters** than the ordinary colloid form. The growing papillæ not infrequently pierce the wall of the cyst and present themselves externally. There may be thus a considerable shaggy growth outside the tumour. Then there may be, in addition, transplantation to other parts of the peritoneum, and the papillæ grow where they are planted. We may in this way have shaggy papillomatous growths surrounding the uterus and other structures in the pelvis and even on the general peritoneum. The rupture of the cysts by scattering the papillæ produces similar results.

This form of tumour is likely to be **less pedunculated** than the former kind. Originating at the hilum, it may grow specially into the broad ligament, distending it and stretching the Fallopian tube, somewhat in the fashion of the cysts of the broad ligament. There are, indeed, cases in which it is difficult to say whether the cyst has originated in the ovary or broad ligament.

4. **Cysts of the broad ligament. Parovarian cysts.**—The cysts included here form a marked contrast to the proper ovarian ones. They have no solid secreting tissue, and their contents are not colloid. They are unilocular, and they show relations to the ovary and Fallopian tube which proclaim their origin in the ala vespertilionis which lies above the ovary, and contains the parovarium. It is natural to infer that they originate in this rudimentary organ, but recently doubts have been raised as to this origin of all these cysts. Hence the general term cysts of the broad ligament is now more frequently in use. It is acknowledged that some of them originate in the parovarium, and, according to Doran, it is chiefly those which show papillomatous ingrowths which do so. At the same time, the general characters of all these cysts are otherwise so similar that one is led to infer a common origin, and they may be grouped together as parovarian cysts.

The cysts of the broad ligament are nearly always **unilocular.** They frequently grow to large dimensions, and they have a perfectly simple connective-tissue wall, without any trace of partitions.

Growing between the two folds of the broad ligament they distend the peritoneum over them, and this **peritoneal covering,** being loosely attached to the proper cyst-wall, can be readily separated. As it has attained to considerable thickness the peritoneal coat itself makes a distinct cyst, like the outer skin of a football. In this respect the cyst differs from the ovarian forms, in which no such layer of peritoneum is distinguishable.

From the position of these tumours, lying in the position of the parovarium between the ovary and Fallopian tube (see Fig. 690, p. 1164), they stretch these structures greatly. The figure shows that a girdle is formed round this part of the broad ligament, by the Fallopian tube, ovarian fimbria, ovary and ovarian ligament. This girdle remains around the cyst but is greatly elongated. **The Fallopian tube** is enlarged and elongated till it may measure fourteen or fifteen inches. The fimbriated extremity is flattened out and exaggerated, while the ovarian fimbria is stretched and thickened. **The Ovary** generally hangs from the lower part of the cyst, elongated and condensed. The ovarian ligament completes the girdle. There is thus no proper pedicle such as ovarian tumours usually have.

The contents of the cyst are usually a clear, colourless fluid, of a specific gravity not greatly exceeding 1008.

In most cases the internal surface of the cyst is smooth, but sometimes intra-cystic **papillary growth** occurs, this form being supposed to be specially parovarian. The papillomatous cysts, like the similar ones of the ovary, show malignant characters.

Rupture of these cysts is not accompanied by the inflammatory manifestations produced by the ovarian cysts. The papillomatous forms, however, may lead to secondary growths by rupture. The ruptured cysts may lie for years in the abdomen, producing little or no disturbance, and without any tendency to refill. This was so in a case observed by Gairdner and the author, and preserved in the Western Infirmary Museum, Glasgow.

5. **Dermoid cysts of the ovary.**—These are sometimes regarded as belonging to the class of **Teratoma.** They are of comparatively frequent occurrence in the ovary, and may be bilateral. In some cases they coexist with the commoner cystic tumour of the ovary. The cyst has a thick connective-tissue wall, and is generally filled with yellow masses of buttery material in which numerous long hairs are entangled. Large quantities of this material may be present.

The cyst has an internal lining of epithelium or epidermis, but in certain areas a more complex structure is developed. Thus sebaceous glands (Fig. 161, p. 324), hairs (Fig. 694), bone, and even teeth may enter into the constitution of the wall.

The sebaceous glands secrete oil which is fluid at the temperature of the body, but on cooling forms a buttery mass. Hairs are shed as from the ordinary hairy parts of the skin, and these accumulate amongst the oil. Epidermic cells are also mixed with it. Teeth are sometimes present, not only in the walls, but in the contents, sometimes to the number of a hundred.

These cysts not infrequently inflame and may rupture, most frequently into the bladder or rectum, their peculiar contents being discharged, and so revealing the nature of the case. According to Bland Sutton, dermoid cysts after rupture may show transplantations on the peritoneum.

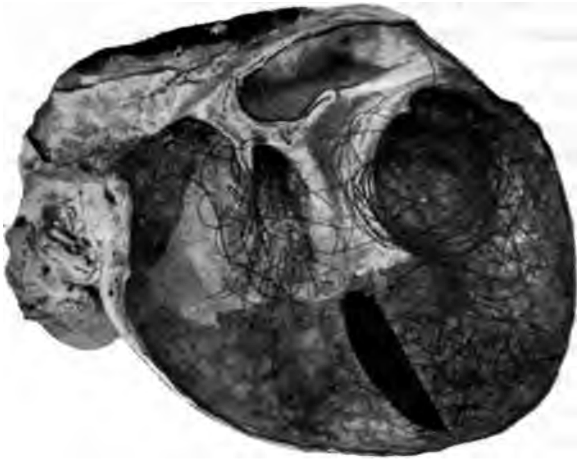


Fig. 694.—Dermoid cyst of ovary.

6. **Cancer of the ovary** occurs mostly **as a Cyst** with cancerous growths in its walls. There may be a combination of the colloid or papillomatous cyst with cancer, or a partial transformation of the former into the latter. In the ordinary ovarian cyst the epithelium has a regular and normal arrangement, and we may call the tumour in that aspect an adenoma; in the cancer the epithelium is distinctly abnormal in its arrangement, being aggregated into indefinite masses. In may happen that in the midst of the cancer the epithelium is undergoing metamorphosis, so that cysts are developing from it as from the more regular granular tissue.

Besides these cancerous cysts we may have a **Solid cancerous tumour** in the ovary, presenting the usual characters, but, like the ovarian tumours, showing a very excessive growth.

7. **Sarcoma** is a rare tumour in the ovary. Spindle-celled sarcoma is the more usual form, but round-celled sarcomas also occur. These

tumours may also assume very large proportions, reaching the size of the head sometimes, and they are not infrequently bilateral. Cysts are frequently present in the midst of them, and these may be simple serous cysts or they may have colloid contents. These latter may arise from glandular structures, and the disease may form a combination of the colloid cystoma and the sarcoma, or they may originate in a softening of the sarcomatous tissue.

Myoma of the ovary forms a hard fibrous-looking tumour.

Fibroma is not a very infrequent tumour. It may grow to very large dimensions, and by softening contain an irregular cystic cavity. The **Chondroma** is a much more unusual form.

Tumours of the Fallopian tubes are excessively rare, but a few cases of papilloma and of cancer have been recorded.

Tubo-ovarian cyst is a name given to a condition occasionally met with in which the end of the Fallopian tube is adherent to and communicates with an ovarian cyst. The tube is itself dilated in some cases, and in some the ovarian cyst discharges into the tube.

The origin of this condition is not always clear. In some cases it is evident that a salpingitis and perimetritis have caused adhesion of the tube to the ovary and occlusion of its orifice, with resulting dilatation. A chronic inflammation of the ovary coinciding may lead to cystic formation in it, by dilatation of the Graafian follicles, and coalescence may result. A colloid cystoma may coincide, but this is a rare circumstance. According to some authors a congenital adhesion of the tubes to the ovaries leads to the tubo-ovarian cyst in some cases.

Literature.—Waldeyer, Eierstock und Ei, 1870; Coblentz, Virch. Arch., lxxxii. and lxxxiv.; Olshausen, Die Krankheiten der Ovarien, in Pitha-Billroth's Handb. der Chirurgie, iv., 1877; Rieder (Gärtner's ducts), Virch. Arch., xcvi.; De Sinety and Malassez, Arch. de Phys., v., vi., vii.; Foulis (Development and structure of ovary), Jour. of Anat. and Phys., xiii.; Balfour (do.), Quart. Jour. of Micr. Science, xviii., 1878; Wilson Fox, Med. Chir. Trans., xlvii., 1864; Spencer Wells, Ovarian and uterine tumours, 1882; Lawson Tait, Path. and treatment of dis. of ovaries, 4th ed., 1883; Doran, Tumours of ovary, tube, and broad ligament, 1884; Howell, in Mann's Syst. of Gynecol., ii., 1888; Bland Sutton, Brit. Med. Jour., i., 1183, 1892; also Surgical diseases of the ovaries, etc., 1891; Williams (with literature), Papillomatous tumours of the ovary, Johns Hopkins Hospital Reports, vol. iii.,1892; Wilms, Ziegler's Beiträge, xix., 1896; Arnsberger, Virch. Arch., clvi., 1899; Seydel, Lubarsch and Ostertag, Ergebnisse, vi., 1901.

B.—The Decidua, Chorion and Placenta.

The pathological changes in these structures have been very imperfectly investigated, and there are many lesions the nature of which is not clearly understood.

The decidua is formed, under the influence of pregnancy, from the mucous membrane of the uterus. This structure is greatly thickened and otherwise altered in structure in order to accommodate the fœtus. The membranes formed by the fœtus are the chorion and the amnion. The former is originally covered by villi, which, in a limited area, go to form the fœtal part of the placenta. The placenta is a joint product of the maternal and fœtal structures, the decidua furnishing the maternal and the chorion the fœtal portion.

1. **Affections of the decidua.**—It is generally believed that diseases of the decidua are common causes of premature discharge of the ovum. but little is known as to their nature. Atrophy and hypertrophy are stated to occur, the latter perhaps as the result of inflammation.

Inflammation of the decidua (*Deciduitis* or *Endometritis decidualis*) apparently leads to various local thickenings and irregularities of the decidua. It occurs when, before pregnancy, there has been a chronic inflammation of the mucous membrane of the uterus. The changes are observed in the membrane discharged along with the aborted fœtus.

Hæmorrhage. The Sanguineous or Fleshy mole.—Hæmorrhage from the decidua is frequent in the course of pregnancy, and may be the cause of abortion.

In some cases the fœtus is retained and the blood accumulates in the chorion and surface of the amnion. The blood coagulates, and, the fibrine condensing the structures, a fleshy mass is produced, in the midst of which the dead fœtus may be no longer discoverable. This mass may remain long in the uterus, to be discharged afterwards as a fleshy mole. Sometimes it is retained so long as to become infiltrated with lime salts, a stony mole being ultimately discharged.

2. **Hydatid mole.**—This is an affection of the chorion, arising by a transformation of the villi. The villi are branching offshoots consisting of mucous tissue, covered by a layer of epithelium (see Fig. 118, p. 292). By increase of the mucous tissue the villi are converted into cyst-like bodies of considerable size. The hydatid mole is thus formed of a mass consisting of the fœtal membranes, on the surface of which are myriads of oval or round cyst-like bodies which hang like grapes on stalks, and often hang on one another (see Fig. 695). Thus a bulky mass is formed consisting of a multitude of these berry-like cysts. On opening the altered membranes as a rule no fœtus is revealed. Occasionally a portion of the embryo may resist absorption in cases of late origin.

In an early stage of development the villi are present all over the chorion, while later on they are limited to a certain area forming the fœtal part of the placenta. If the disease begins early the cyst-like bodies are present all over the chorion, whereas in later periods they occupy only the placental surface.

The altered chorionic villi adhere to the wall of the uterus, and sometimes are even embedded in its substance, so that when removed the internal surface may be like that of the heart, showing prominent trabeculæ. There may even be a destructive encroachment on the uterine wall.

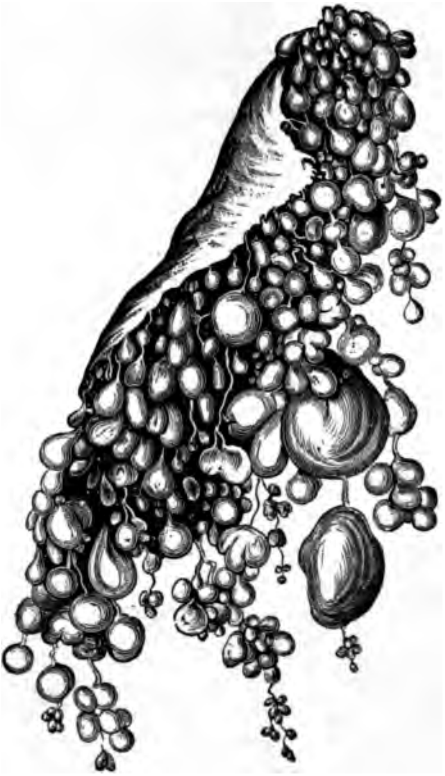


Fig. 695.—Portion of a hydatid mole showing the berry-like masses. Natural size. (VIRCHOW.)

The hydatid mole grows quickly, so that the enlargement of the uterus goes on more rapidly than in a normal pregnancy. The mole is detached at first in pieces, along with hæmorrhage, and even when the bulk of it is discharged, it may be so mixed with blood as to be with difficulty distinguished. The clear grape-like bodies afford the means of distinction.

3. **Diseases of the placenta.**—The placenta, being rapidly formed and being composed of a tissue intended for temporary purposes, is specially liable to various degenerations and to disorders of the circulation.

Hæmorrhage occurs in the placenta not infrequently, producing localized collections of blood, the condition being called **Apoplexy** of the placenta. The placenta villi are embedded in the coagulum and somewhat concealed.

The White infarction is a somewhat frequent lesion in the placenta. It is found in cases where the child has been still-born, and it implies grave disturbance of the circulation in the placenta. The infarction forms a solid white mass, usually wedge-shaped, and generally multiple. In it the villi are dead, and fibrine or blood lies in the spaces. The lesion has arisen by a process of **Coagulation-necrosis** like the pale embolic infarctions of the kidney and spleen.

The cause of this localized necrosis is not clear. There is probably an arterial obstruction, which Ackermann has ascribed to a periarteritis nodosa. According to Kustner serious nutritive disturbances during pregnancy are regularly followed by the formation of numerous white infarctions of the placenta.

Inflammations of the placenta are described as leading to fibrous thickenings. The inflammation originates in the decidua and extends to the placental tissue.

A Periarteritis nodosa has been mentioned above as having to do with the formation of the white infarction. It appears indeed that these infarctions are often regarded as due to inflammations. The whole subject is in need of further elucidation.

Syphilis leads in the placenta to new-formation of granulation tissue and gummata, causing the placenta to increase in bulk and weight. From the pressure of the new-formed tissue on the vessels, there is apt to be degeneration of the placental structures. **Tuberculosis** has also been described as occurring in the human placenta.

Retrograde changes are frequent in the placenta. Fatty degeneration and calcareous infiltration occur in the various structures. The placenta is sometimes speckled all over with small whitish spots, which are areas in which calcareous deposition has occurred. Along with this the microscope reveals fatty degeneration.

Œdema as a result of obstruction to the fœtal circulation or owing to some maternal cause may occur. The placenta is large and heavy.

Tumours.—Both cystic and solid tumours have been described. They are very rare. Cysts are found under the amnion varying in size from a pea to a walnut. They contain mucous fluid, and may originate in extravasations of blood. Both forms of tumour are most frequently found on the fœtal surface and near the insertion of the cord.

Abnormalities in form, size and situation are common.

4. **Deciduoma malignum** or **chorion-epithelioma** is a form of tumour the precise nature of which has given rise to endless discussion. By

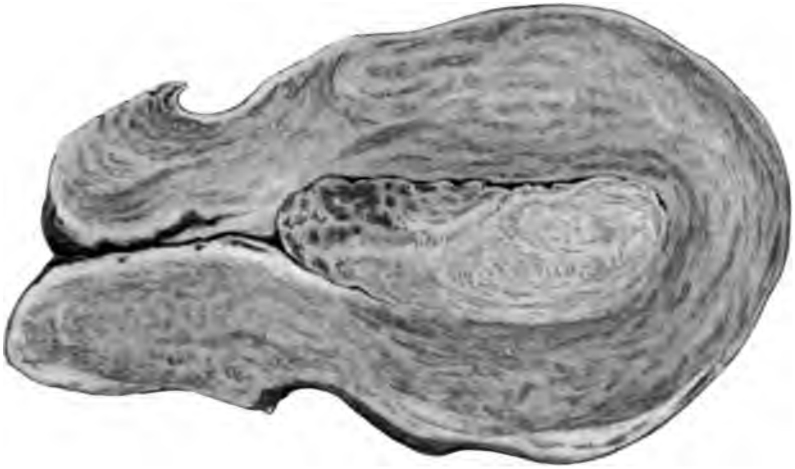


Fig. 696.—Deciduoma malignum or chorion-epithelioma. (Dr. Buist's Case.)

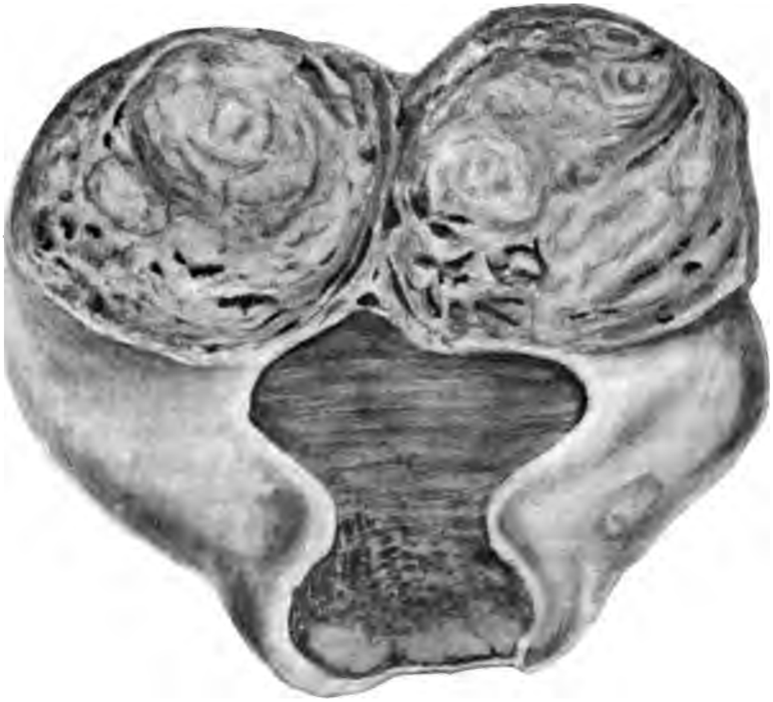


Fig. 697.—Deciduoma malignum or chorion-epithelioma. (Dr. Buist's Case.)

the term **Deciduoma** a relationship with the decidua is implied, but recent investigation points rather to the epithelial coverings of the villi of the chorion as the seat of origin of the affection. The term **Chorionic-epithelioma** is thus preferable.

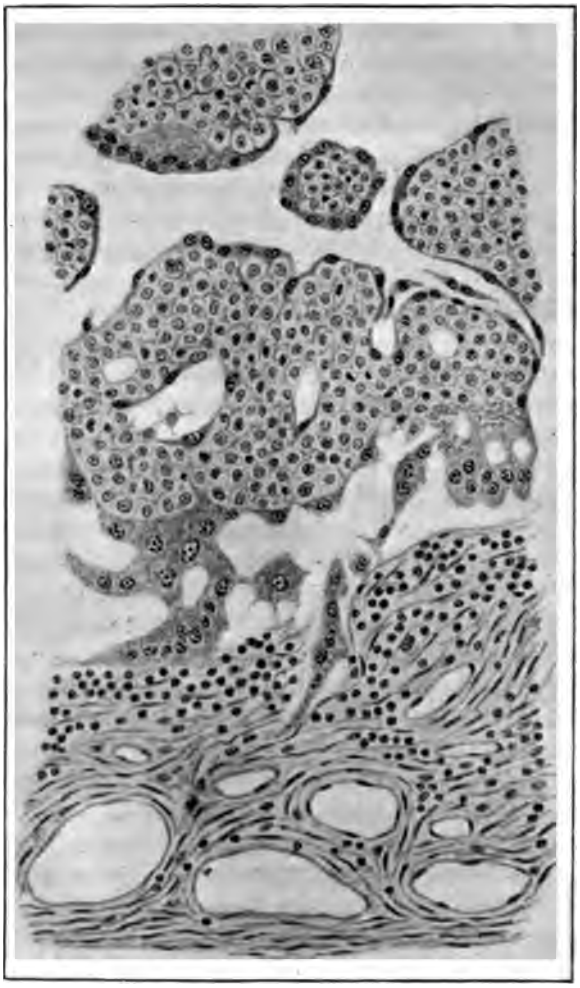


Fig. 695. - Deciduoma malignum or chorion-epithelioma invading uterine wall. × 250.

The growth arises in the great majority of cases in connection with pregnancy. In many instances it appears after a molar pregnancy, and especially after the vesicular or hydatid form. As a rule it projects from the inner surface of the uterus (Fig. 696) in the form of a somewhat friable brown mass resembling blood clot. In the midst of this pale areas of tumour tissue and more opaque areas of necrosis are commonly visible. In some cases the growth is for the most part embedded in the uterine wall (Fig. 697). It may remain local, but frequently shows metastasis in various organs, *e.g.* the vagina, lungs (Fig. 555, p. 916), liver (Fig. 623, p. 1042), etc., the metastases closely resembling the primary tumour.

On microscopic examination two types of cells are distinguishable (Fig. 698). There are cells with clear protoplasm and rounded or oval nuclei, which stain somewhat faintly with nuclear stains, and show a distinct intranuclear network. These form the bulk of the tumour, and are in all probability derived from **Langhans' layer** or the inner epithelial investment of the chorionic villus. Further protoplasmic masses or **Plasmodia** of irregular outline containing oval nuclei also occur, and are most probably to be referred in their origin to the **Syncytium** or outer epithelial layer of the villus.

The discovery within recent times of these cellular elements in certain tumours of the testicle, while tending to render the problem more complex, may yet be a means of throwing light upon this interesting form of tumour.

Literature.—SPIEGELBERG, Text-book of Midwifery (Syd. Soc. trans.), 1887. *Hydatid mole*—VIRCHOW, Geschwülste, i., 409; VOLKMANN (Destructive mole), Virch. Arch., xli.; JAROTZKY and WALDEYER (do.), ibid., xliv. *Placenta*—MAIER (Inflammations), Virch. Arch., xlv.; ACKERMANN, ibid., xcvi.; KUSTNER, ibid., cvi.; VIRCHOW (Syphilis), Geschwülste, ii., 480; FRAENKEL, Ueber Placentalsyphilis, 1873; SCHMORL u. KOCKEL (Tuberculosis), Ziegler's Beiträge, 1894, xvi., p. 313; KERMAUNER (Hydatid mole), Monatschrift für Geburtshülfe, etc., xvi. 2, 1902. *Deciduoma*—MARCHAND, Zeitschr. f. Geburtsh. u. Gynäk., xxxii., 1895, xxxix., 1898; WILLIAMS, Johns Hopkins Hosp. Rep., iv., 1895; RUGE (literature), Lubarsch and Ostertag, Ergebnisse, i., 1896; EDEN, Journ. of Path. and Bact., iii. and iv., 1896, 1897; ASCHOFF, Lubarsch and Ostertag, Ergebnisse, v., 1900; TEACHER, Brit. Med. Journ., June and July, 1903, and Journ. of Obstetrics and Gynæcol. of British Empire, July, 1903; SCHLAGENHAUFER, Zentralb. f. Gynäk., xxvii., 1903; CAREY, Johns Hopkins Hosp. Bull., xiii., 1902.

C.—THE MAMMARY GLAND.

The mammary gland is very frequently the seat of tumours. It is also very liable to inflammations, especially during lactation.

I.—MALFORMATIONS, INFLAMMATIONS, ETC.

1. **Malformations of the breast.**—One or both mammæ may be absent. It is more frequent, however, to have supernumerary breasts or nipples, sometimes three, four, or even five, instead of two. The

supernumerary breasts are usually situated near the axillæ, or under the normal ones. But there are cases in which they have had a very abnormal situation, as in the inguinal region, on the thigh, or even on the back. They are usually small in size, but in some cases they have produced milk during lactation. Supernumerary breasts are more frequent in males than females, and they occur preponderatingly on the left side. The occurrence of additional mammæ is not altogether extraordinary, considering that in the lower animals the mammæ are usually more in number than in man.

2. **Inflammation of the mamma. Mastitis.**—This occurs not infrequently about the period of puberty or in connection with menstruation, but in the majority of cases it is related to lactation. In connection with lactation, and especially at its commencement, the structures in the mamma are the seat of very active processes; there is hyperæmia and an active secretion of milk. Under these circumstances inflammation is more readily induced than usual, but in cases of acute, and more particularly suppurative inflammation, the actual presence of an irritant must be inferred. It may happen that contraction of the arteries from accidental circumstances, such as exposure to cold, is capable of setting up inflammation. Even a general irritation of the vaso-motor centre, when the skin is exposed to cold, may, by reflex action on the highly excited vascular system of the mamma at the commencement of lactation, strongly predispose to inflammation. The actual irritant finds access in most cases by the nipple and lactiferous ducts. In many cases it takes origin in cracks and ulcers of the nipple, the irritant which has caused the lesion in the nipple extending along the tubes and causing inflammation in the mamma. On the other hand, an infective agent may extend along the ducts from without, apart from any preceding lesion of the nipple.

The inflammation is usually an acute one, and is accompanied by exudation, the interstitial tissue being packed with leucocytes and the breast hardened. This hardening is often local, as the inflammation is usually to some extent limited to certain parts of the breast. Very often the exudation of leucocytes goes on to actual suppuration and the formation of **Abscess**, sometimes with sloughing of the tissue. The abscess so formed may have extensive ramifications in the mamma, especially if the pus does not discharge externally. After evacuation the cavity fills with granulation tissue, and finally closes, and a cicatrix is formed.

A **Chronic inflammation** resulting, after the usual manner of interstitial inflammations, in induration of the organ, has been described, but is not of very frequent occurrence.

3. **Hypertrophy of the mamma.**—In some cases the mammæ undergo a progressive enlargement from the new-formation of proper mammary tissue. In this way the gland may come to weigh as much as thirteen pounds. It is to be remembered that a simple enlargement of the fat around the mamma (*lipoma capsulare*) may imitate hypertrophy, which may also be simulated by diffuse tumours of the gland.

4. **Tuberculosis of the mamma.**—This, although probably rather frequent, has only recently been fully recognized, notwithstanding that conditions of the breast designated scrofulous have been long known. There may be isolated or confluent caseous masses which undergo softening and may open spontaneously on the surface. The result is usually the establishment of a fistulous opening. Probably many of the cases of chronic mastitis and of cold abscess are tubercular (see Fig. 699).

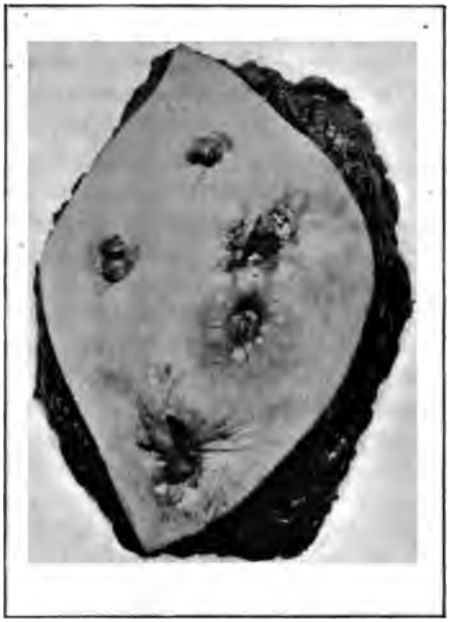


Fig. 698.—Tuberculosis of the mamma. Four abscesses are seen to have come to the surface.

The tuberculosis of the mamma may be secondary to that of the lungs or other organs, but it may be primary. According to Verneuil the bacilli may find entrance by the milk ducts, and multiply in the glandular structures.

Tuberculosis of the udder occurs not infrequently in cows which are the subject of tuberculosis of other parts. This fact is of importance because the bacilli frequently find their way into the milk in such cases.

5. **Syphilis of the mamma.**—This is very uncommon, but cases of gumma in the breast have been recorded.

Literature.—*Malformations*—Scanzoni, Krankh. der weibl. Brüste, 1855; Velpeau, Traité des malad. du sein, 1858; Maschat, Anom. de la mammelle, 1883; Mitchell Bruce, Jour. of Anat. and Phys., xiii.; Sneddon, Glasg. Med. Jour., x., 1878; Leichtenstern, Virch. Arch., lxxiii., 1878; Champneys, Med. Chir. Trans., 1887. *Hypertrophy*—Labarrague, Hypertr. générale de la gl. mammaire, 1875; Olphan, L'Hypertrophie mammaire, 1880. *Tuberculosis*—Durant, New York Med. Jour., 1884; Dubar, Des tuberc. de la mammelle, 1881; Verchère (Verneuil), Des portes d'entrée de la tuberculose, 1884; Berchtold, Ueb. Mammatuberculose, 1890; Roger Williams, Dis. of breast, 1894; Scudder, Amer. Journ. Med. Sciences, cxvi., 1898. *Syphilis*—Gromo, Contrib. a l'étude des gommes du sein, 1878; Hutchinson (Chancres on nipples), Syphilis, 1887, pp. 101 and 118; Landreau, Syphilomes mammaires, 1874; Lancereaux, Traité de la Syph., 1866; Bumstead and Taylor, Treat. on vener. dis.

II.—TUMOURS OF THE MAMMA.

The female breast is one of the most frequent seats of tumours, and they present considerable variety in form.

As the two constituents of the breast are the proper glandular structures and the connective-tissue stroma, so tumours are derived from one or other of these, and belong to the connective-tissue or epithelial forms. But the connective-tissue tumours do not originate in a particular small piece of tissue, and grow so as to displace the remaining structures; on the contrary, they usually involve a considerable portion of the gland and sometimes its whole extent. Hence they enclose more or less the glandular elements, and it may be impossible to say whether these are increased so as to form an integral part of the tumour. Moreover, these glandular elements are subject to great alterations, consisting of contortions and dilatations, which also give their character to the tumours, producing fissures and cysts in them. Again, the tumour tissue frequently grows into the cysts, producing the so-called intracystic growths, which sometimes assume a papillomatous character.

It will be inferred that the distinction between connective-tissue and glandular tumours is frequently difficult, and that dilatation of the gland structures, implying, as it does, new-formation of these, gives a partly glandular character to a large proportion of the tumours.

The atypical mammary tumours show a great preponderance in frequency, especially the cancers. According to statistics collected by

Gross, there were in 973 tumours, 832 cancers (85·5 per cent.), and 77 sarcomas.

Amongst the typical tumours, the lipoma, chondroma, and myoma are excessively rare, and require little notice.

Lipoma occurs doubtfully as a solid tumour in the midst of the gland. The **Lipoma capsulare** is also rare. In it the adipose tissue around the gland undergoes great increase, while the gland itself atrophies. Such tumours may assume enormous dimensions, weighing up to 100 pounds.

Chondroma rarely occurs as an independent tumour, but cartilage is sometimes found in sarcomas and cancers. **Bone** sometimes exists in fibromas, causing a partial conversion of them.

Myoma (leiomyoma) sometimes develops in connection with the nipple. Billroth observed a case in which striated muscle existed in an adeno-sarcoma.

1. **Adenoma and Fibroma. Adeno-fibroma.**—The boundaries between the adenoma and fibroma are not well marked. They are both slow-growing, non-malignant tumours, generally of hard consistence, distinctly encapsuled, and not infrequently multiple. Many tumours which are regarded as glandular by some authors are described as fibromas by others.

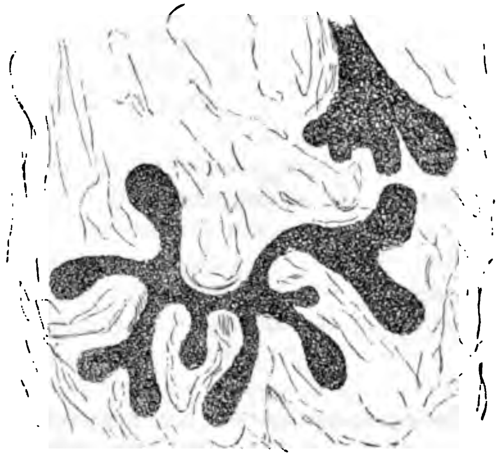


Fig. 700.—Section of an adenoma of mamma. Glandular structures of well-formed outline are shown in the midst of fibrous tissue. × 90.

The **Adenoma** is a purely glandular tumour. It occurs either in the substance of, or in the neighbourhood of the gland. It has a fleshy feel and a lobulated outline. On section it is white in colour and frequently shows cysts, but without intracystic growth.

There is preserved in the Museum of the Western Infirmary, Glasgow, a glandular tumour whose situation was behind the gland, which had to be cut through in order to remove it. The tumour was almost like a supernumerary mamma. and had to the naked eye and microscopically very much the structure of an inactive mamma (see Fig. 700). The tumour was removed from a young lady aged 21, and had been observed for two years. Towards the end it grew more rapidly.

Under the microscope the adenoma presents elongated and enlarged acini and ducts (see Figs. 700 and 701), and these commonly show dilatation, so that cysts are present in the majority of cases.

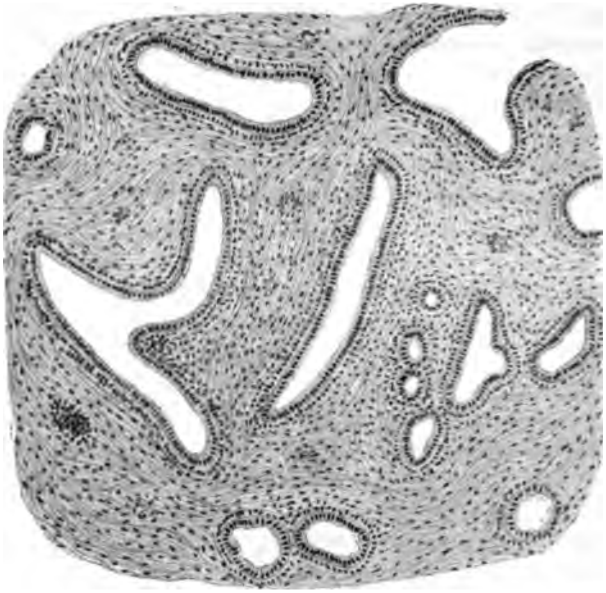


Fig. 701.—Mammary adenoma. Gland tissue with partial dilatation of duct.

The **Fibroma** or **Adeno-fibroma** is a hard fibrous tumour, generally with a lobulated outline, and distinctly encapsuled. On section it shows a glistening, fibrous appearance, but this is rarely homogeneous. There are usually, even to the naked eye, indications of the presence of glandular structures, and these are often dilated into cysts. The whole tumour may be a congeries of cavities, which only partly contain fluid, but are largely filled up with foliaceous or dendritic structures composed of tumour tissue projecting into them.

These tumours are sometimes the seat of calcareous deposition and of osseous formation. There may be a partial myxomatous transformation leading in this way to cysts.

Under the microscope wavy fibrous tissue predominates. There are also glandular structures visible, which are either ill-developed or contorted and dilated as in Figs. 701 and 702.

2. **Myxoma.**—In this rare form of mammary tumour, the mucous tissue develops from the stroma of the gland, and it may involve one or more lobules, or the whole gland, which is then converted into a bulky tumour. Sometimes the mucous tissue grows into the milk ducts, forming the *Myxoma intracanaliculare arborescens* of Virchow.

The tissue may be pure mucous tissue (see Fig. 119, p. 293), but it is subject to various modifications. It may be unduly cellular so as to approach to the sarcoma, or it may be mixed with fat or fibrous tissue. It also contains glandular tissue, which may be dilated into cysts.

This form is more malignant than the adeno-fibroma, being more liable to recur after removal.

3. **Sarcoma. Adeno-sarcoma. Cysto-sarcoma.**—The two last-mentioned names imply that the glandular structures take an important part in giving character to sarcomas of the mamma, although the connective-tissue structures are those essentially engaged.

The line of demarcation between the sarcoma and the fibroma is not absolutely distinct, and there seems no doubt that the latter may develop into the former by an atypical process of growth supervening.

The spindle-celled sarcoma is the commonest form. The cells are usually small, and there may be a considerable amount of fibrous intercellular substance. The tumour is usually hard and variously modified by the presence of gland tissue. The round-celled sarcoma is unusual, and generally forms a soft tumour. The cells may be so small as to be like lymphoid cells, or they may be larger. The giant-celled sarcoma is very rare. In addition to the small cells which compose the greater part of the growth, there are large multi-nucleated cells sometimes of very great size. The pigmented sarcoma is also rare; the cells are usually round, but sometimes spindle-shaped.

The sarcoma is generally solitary. It may be distinctly demarcated, occupying a small part of the breast, but it not infrequently extends so as to involve the whole mamma. It may grow slowly, but is apt, after a period of slow growth, suddenly to enlarge rapidly.

The **Adeno-sarcoma** is a tumour in which the glandular structures are specially abundant. It is usually a small comparatively isolated tumour, somewhat resembling the adeno-fibroma, and, like this tumour, it is not infrequently multiple. Under the microscope it usually shows abundant glandular structures somewhat contorted, with a spindle-celled tissue between.

The **Cysto-sarcoma** shows many gradations. There may be such simple dilatations as those indicated in Fig. 702, or there may be large cavities. Great complication is sometimes produced by intracystic growth of the sarcomatous tissue, as in the cystic-fibroma.

Besides these variations due to the mixture with glandular tissue, the sarcoma is subject to other modifications. It may contain **Cartilage**, as in the case from which Fig. 703 was taken. In this case the tumour contained well-formed fibrous tissue and cartilage, but also, apparently as a more recent development, spindle-celled tissue, and a tissue consisting of closely aggregated cartilage cells with little hyaline matrix. Bone also occurs occasionally.

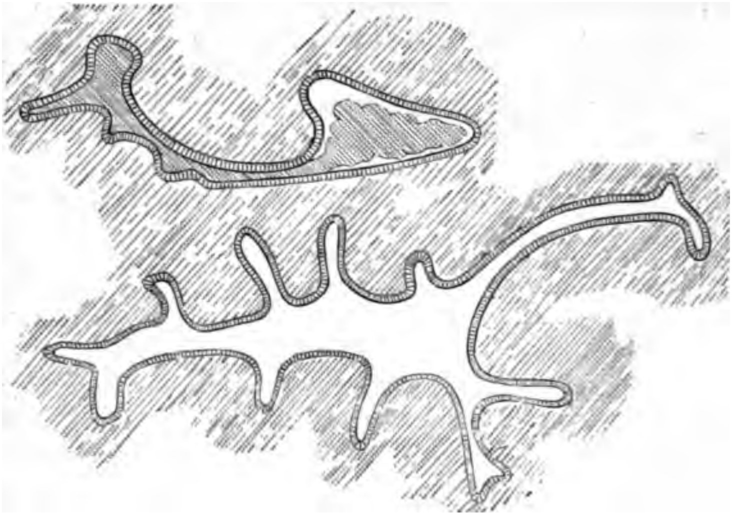


Fig. 702.—Semi-diagrammatic view of dilated glandular spaces in a cysto-sarcoma of the mamma. The spaces are lined with cylindrical epithelium. The tendency to intra-cystic growth is shown, especially in the upper one. × 62.

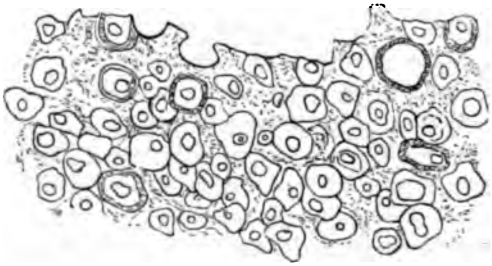


Fig. 703.—Section of cartilaginous part of a tumour of mamma which contained also spindle-celled and fibrous tissue. × 200.

Mucous transformation sometimes occurs, and cysts may arise in this way. There is also fatty degeneration, calcareous infiltration, and hæmorrhage, especially in the quickly-growing and softer forms.

Sarcomas are **very malignant**. On removal they are even more apt to return than cancers, and they also tend by metastasis to give rise to secondary tumours in internal organs, the metastasis occurring by the blood.

4. **Cancer of the mamma.**—According to what has been stated in the general section of this work, we have, in cancer, an aberrant growth of epithelium as the foundation process. In the more usual or **ordinary cancers** the process begins in the **glandular acini**. At the growing margin of the tumour the epithelium of the acini is seen to be proliferating, so that the acini are distended and enlarged. Along with the new-formation of epithelium in the acini there is a formation of round cells in the connective tissue around. The epithelium of the acini next grows through the basement membrane, forming penetrating processes, and the round cells develop connective tissue which frequently causes great contraction of the tumour (Scirrhus). It is as if the epithelium, growing outwards, acted as an irritant, causing inflammatory new-formation in the interstitial tissue of the gland. Where the case is very chronic the connective-tissue formation may be very pronounced, but when more acute the epithelial elements preponderate.

A special group of cases has been distinguished by Thin under the name of **Duct cancer.** The peculiarity of this class is that the lesion begins in the large ducts near the nipple, and extends from these, first to the smaller ducts and then to the glandular parenchyma. The ducts, larger and smaller, are distended with growing epithelium. The tumour in the gland itself has the characters of ordinary cancer, so that the name duct cancer refers chiefly to the mode of invasion.

Paget's disease or **Eczema of the nipple,** also called **Darier's disease,** frequently precedes or accompanies cancer of the mamma, and the form of cancer is Duct cancer. This association is important, from the fact that in Paget's disease coccidia are stated to occur in the epithelium. Eczema, as indicated in the section on Diseases of the Skin, is an inflammation of the skin, in which both the epidermis and the superficial layers of the cutis are involved. The superficial or papillary region of the skin may be replaced almost entirely by round cells, and the condition is somewhat like that of a granulating wound. The epithelium of the surface takes little part in the process, and it may be lost, so that the granulation tissue is exposed. The connection of this disease with cancer is not perfectly clear. Perhaps the most probable suggestion is that the causative agent begins by acting on the surface structures, and afterwards extends by the nipple into the ducts, producing duct cancer. A further extension into the gland leads to the lesions of ordinary cancer.

According to Thin, however, the cancer of the ducts is present from the first, but is concealed by the eczema.

In its atypical growth the glandular epithelium sends its processes into the **Lymphatic spaces** of the connective tissue. There is commonly a further extension to the lymphatics outside the gland. These are sometimes seen distended by cancerous growth, but even without this obvious involvement the infection has often spread to the axillary glands. These may be but slightly enlarged and yet the seat of distinct cancerous new-formation.

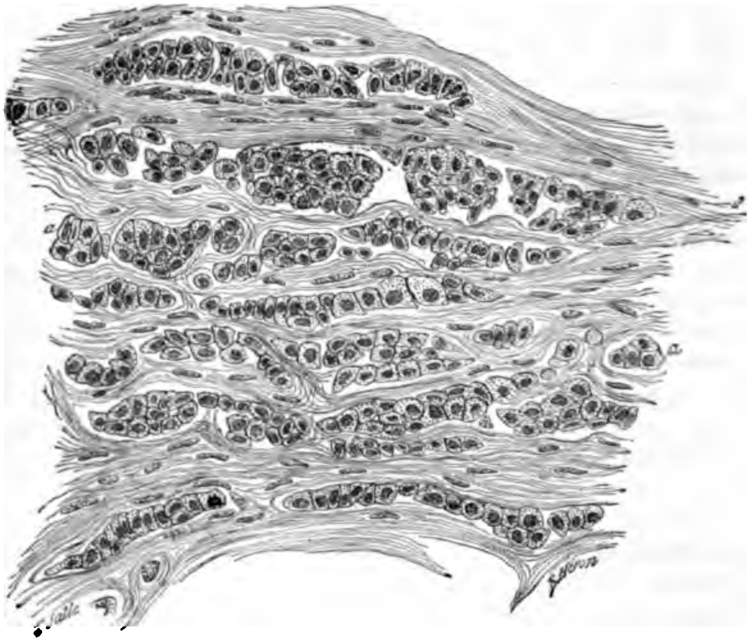


Fig. 704.—Section of cancer of mamma from a recent nodule. Epithelial cells in spaces formed by connective tissue; these are sometimes in single rows, and by multiplication form larger masses. × 200. (CORNIL and RANVIER.)

Forms of cancer of the mamma.—The various forms are not absolutely separable one from the other. They all originate in the glandular structures, and they are distinguishable chiefly by variations in the proportion of cells and stroma, and also by the transformations of these.

(*a*) **Fibrous cancer. Scirrhus.**—This is the commonest form, constituting about 95·5 per cent of the cases (Gross). The epithelial masses form elongated processes (see under Cancer) in the midst of an excessive stroma composed of fibrous tissue. The epithelial cells are often atrophied so that in some parts of the tumour there is little beyond dense connective tissue. The cancer commonly forms a limited infiltration of a part of the gland rather than a proper tumour, and as the tissue contracts there is commonly an **actual diminution of bulk** with great induration. The gland is distorted and puckered towards the affected part.

Very often the disease is continuous with the **nipple**, and by the contraction of the tissue the nipple is drawn in, sometimes even forming an umbilicated depression. The tumour is very irregular in its extension in the gland, and it very often happens that in the midst of hard scirrhous tissue some **Adipose tissue** appears. In like manner pieces of the gland tissue may crop up amidst the contracting tumour.

The skin is frequently involved in the cancer. The cancer reaching the skin sends narrow processes of epithelium amongst the connective tissue, which forms the cutis vera, so as to produce an infiltration and thickening of this structure. When the skin is largely replaced by the cancerous tissue **Ulceration** usually occurs, generally beginning about the site of the nipple and areola. The ulcer, at first a mere excoriation, is liable to become crater-shaped with dense prominent walls. Sometimes after the formation of the ulcer the growth of the tumour becomes more rapid.

When the mamma is cut into, either the whole gland or a portion of it is seen to be occupied by a dense mass of a greyish colour on the cut surface. It is very hard to cut, and the cut surface is commonly concave, the elasticity of the dense connective tissue producing retraction. In the general grey basis there are various whitish or yellowish pieces which represent the remains of mammary or adipose tissue, or the cancerous epithelium in a state of fatty degeneration. If the cut surface be scraped a **thickish juice** is obtained, which microscopic examination shows to be composed of epithelial cells and their debris. Many of the cells are large and well-formed though variously shaped, while some may contain enclosures which, under the newer views, are regarded as parasitic. The cells have often double nuclei (see Fig. 705). There are also free nuclei which have escaped from cells as a

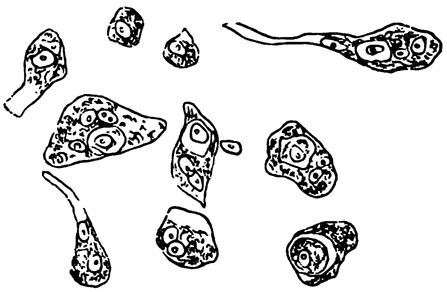


Fig. 705.—Cells in the juice scraped from a scirrhus of the mamma. They are of very irregular shape. Most of them contain several nuclei. × 200.

result of mechanical interference in the process of preparing the specimen. Many of the cells present fatty degeneration; in fact, very often nearly all contain fatty granules, and there are some completely degenerated, showing nothing but an aggregation of fat drops like the compound granular corpuscle.

The secondary tumours in the lymphatic glands also show an excessive development of fibrous stroma, which, however, usually forms a more distinct meshwork than that in the mamma while the epithelial cells form more definite groups.

(*b*) **Soft or Acute cancer.**—This forms the opposite extreme to scirrhus, and there are all intervening grades. In the soft cancer we have a bulky tumour of soft consistence and rapid growth. There is a well-formed alveolar stroma, and the cells are somewhat loosely contained in it. The tumour involves neighbouring tissues, very readily infiltrating the skin, subjacent muscle, and even the osseous ribs and the pleura. This form is sometimes present simultaneously in both breasts. On section the tumour presents a grey brain-like appearance. The juice furnishes numerous cells, which are arranged in groups. As the tumour commonly extends to the skin, we may have ulcers with fungating prominence of the tissue. The lymphatic glands are early affected, and they also may ulcerate.

Many large tumours of the mamma of comparatively rapid growth do not correspond with the description either of the soft or medullary cancer or of scirrhus. In their minute structure they are more like scirrhus, and perhaps may be designated **Acute scirrhus.** They have a remarkably fine fibrous stroma, which forms distinct meshes containing the epithelial masses more or less regularly disposed. The cancer cells are large and essentially like those in scirrhus. The tumour as a whole is hard, owing to the abundance and density of the stroma.

(*c*) **Colloid cancer.**—As compared with scirrhus, this is a rare form of tumour, constituting about 1·34 per cent. of the total cases. Colloid degeneration may affect the cells of an ordinary cancer, producing a partial metamorphosis, but in true colloid cancer the tissue as a whole presents from the first a tendency to colloid degeneration. The entire mamma is commonly affected, and is greatly enlarged, while it presents a hard feel like that of acute scirrhus. On section the tumour has a flickering gelatinous appearance. Under the microscope there is the usual pronounced stroma with colloid material in the meshes. In the midst of the colloid masses there are often seen groups of cells, the remains of the epithelium (see Fig. 203, p. 367).

A very infrequent variety is sometimes described as **Mucous cancer.** It forms a large gelatinous tumour which, on microscopic examination, shows epithelial masses embedded in a gelatinous flickering stroma. It is probably a variety of colloid cancer.

Cysts are not of frequent occurrence in cancers, but in some cases cystic formation is so characteristic as to warrant the name of **Cystic cancer.**

5. **Cysts of the mamma.**—It has been already pointed out that cysts frequently complicate other tumours, especially adeno-fibromas or sarcomas, and sometimes cancers. Cysts also occur independently, and they too originate most frequently in the gland structures.

Most cysts of the mamma belong to the group of **Retention cysts,** arising in consequence of obstruction of the ducts. The cause of obstruction is sometimes an interstitial inflammation, and in that case the cysts will usually be small and multiple, just as they are in the kidneys in interstitial nephritis. In other cases the cause is obscure, and as the cysts may assume a large size their origin is perhaps embryonic.

(1) **Multiple cysts in old people** (*Involution cysts*) occur in connection with the involution of the gland. The cysts are usually small, about the size of small shot or hemp-seed, but may be larger. When unopened they have a greenish or blackish appearance, and they contain a glairy fluid in which fat and epithelial cells are present.

(2) **Simple cysts** may grow to a large size, forming tense thin-walled sacs. They are usually single, but if of small size they may be multiple. Their contents vary considerably, being usually serous or sero-sanguineous, but sometimes they are deep brown in colour, and contain fat and cholestearine. In some cases they contain milky fluid, in which case they are called galactoceles.

(3) **Galactoceles** or **Lacteal cysts** arise usually when the gland is active. They are found chiefly in the neighbourhood of the nipple, arising by dilatation of the larger ducts. They contain milk, usually like ordinary milk, but sometimes altered so as to resemble cream or thickish oil, or curd, or butter. These cysts are usually solitary, and are rare.

(4) **Connective tissue cysts** have been described and are supposed to be of lymphatic origin. They have thick walls and indurated connective tissue around them. Hence they resemble scirrhus in their clinical aspects. The internal surface is lined with flat endothelium. The cysts are single or multiple.

Parasites in the mamma.—The only parasite of any consequence is the **Echinococcus** which forms hydatid cysts. These may be with difficulty discriminated from simple cysts, and as there is sometimes considerable induration around them, they may also be mistaken for cancers.

The **Cysticercus cellulosæ** has also been observed in the mamma (Guermonprez).

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Subsection II.—DISEASES OF THE MALE GENERATIVE ORGANS.

A.—The Testicle and Tunica Vaginalis.

1. **Malformations and Misplacements of the testicle.**—The testicle may be absent on one or both sides, while the vesiculæ seminales and vasa deferentia are perfect. Or the vas deferens may be deficient while the testis is well developed.

Imperfect descent of the testis, or **Cryptorchismus,** is a very frequent and important condition. The descent of the testis occurs normally before birth, but in a considerable number of cases the organ has not yet appeared externally at birth. In the majority of such cases it comes down within the first week, but it is sometimes delayed for months or a year, or even till puberty. When thus delayed the descent is very often imperfect, so that the gland remains in the inguinal canal or at the ring. On the other hand, the testis may be retained throughout life in the abdomen. The testicle retained in the abdomen or on the way down is usually **imperfectly developed,** and although apparently of normal size, it does not generally contain spermatozoa in its tubules. It is also more prone to **Inflammation** and to the **Formation of tumours** than the normally placed testis, especially when retained in the inguinal canal, where it is exposed to external violence. **Gangrene** is also of occasional occurrence in a retained testicle. It may arise from inflammation occurring while the testis is in a restricted space, more especially in the groin, or it may result from torsion of the cord including its artery. When it is late in descending, the accompanying pouch of peritoneum, which forms the tunica vaginalis, is apt to remain open and so to induce a **Congenital hernia.**

Besides these congenital misplacements, we may have the testis descending into the crural canal, or into the perineum.

2. **Inflammation of testicle and epididymis. Orchitis. Epididymitis.**—Most inflammations begin in the epididymis, and may remain limited to it or extend to the testicle. As regards its causation two groups of cases are recognizable, one in which an affection of the urethra has preceded the disease, and the other in which the infection has occurred through the blood.

To the first group belong cases of urethritis, chiefly gonorrhœal, also cases in which the inflammation has succeeded catheterization. In explanation of the transference of the inflammation from the urethra to the testis the terms metastasis and sympathy have been used. It may be that reflex contraction of the vessels of the testicle may induce an orchitis, but there seems little doubt that in most cases there is an actual propagation of the inflammation by the vas deferens. In the case of gonorrhœa as well as in septic urethritis following catheterization, symptoms of inflammation along the vas deferens have been noted.

Orchitis is an occasional accompaniment of Parotitis or Mumps. It is probable that here the two local manifestations are due to the specific infection which is present in the blood. Orchitis also occasionally accompanies or succeeds certain other general diseases, such as typhoid fever, small-pox, gout, scarlet fever, and acute tonsillitis.

The inflammation usually begins in the epididymis, and generally remains almost limited to that structure. There is hyperæmia and serous exudation producing great swelling. At the same time there is often serous fluid in the tunica vaginalis. The testis itself is usually but slightly swollen. There may be resolution without suppuration, or the disease may become chronic, or suppuration may occur. In the latter case an abscess or abscesses form in the epididymis or testicle, and these may burst externally. On the other hand, the abscess may dry-in and form a caseous mass, which becomes surrounded by a fibrous capsule. This mass may ultimately become calcareous.

Chronic orchitis may arise out of an acute attack, whether suppurative or not. Most cases of so-called spontaneous orchitis are really syphilitic or tubercular. The ordinary chronic orchitis is characterized by new-formation of connective tissue in the stroma of the organ, and consequent induration of it. The tubules atrophy and the whole organ is reduced in bulk and hardened. Generally on section it can be seen.

that the tunica albuginea and the septa, which proceed towards the mediastinum, are greatly thickened. At the same time there is frequently adhesion of the tunica vaginalis so as to obliterate the sac.

3. **Syphilitic disease of the testicle.**—This occurs in two forms, namely, as a late manifestation of the secondary stage or as a tertiary lesion. In the former case there is a generalized inflammation leading to induration like a chronic orchitis. The albuginea is thickened and the trabeculæ are enlarged as they converge towards the mediastinum. In the tertiary form there is more abundant granulation tissue along with gummata. The gummata may undergo caseous necrosis, and by coalescence of neighbouring tumours we may have considerable masses of caseous material. In the midst of this caseous material the outlines of the seminal tubes can sometimes be made out, indicating that the necrosis has overtaken the proper tissue as well as the new-formed.

4. **Tuberculosis of the testicle.**—This is a somewhat frequent disease, occurring not uncommonly in childhood and youth. The path by which the tubercle bacillus reaches the organ has not been unequivocally determined. The fact that the epididymis is usually the primary seat suggests an extension from the urethra, as in the case of gonorrhœal epididymitis. But in the present case tuberculosis of the urethra does not precede that of the testicle, and it is difficult to believe that the bacilli can travel up the long urethra of the male and thence along the vas deferens, in both cases against the current of the fluid conveyed by these tubes, in order to lodge in the epididymis, and that without producing any disease in the passage. It is more probable that infection is through the blood, the condition being analogous to tuberculosis of the bones. This conclusion is confirmed by the fact that injury to the testis is undoubtedly, in some cases, an element in the causation.

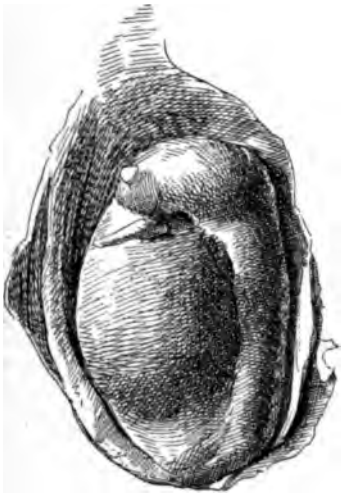

Fig. 706.—Tuberculosis of testicle. The epididymis is greatly enlarged and partly surrounds the testicle.

As a general rule the tuberculosis begins in the epididymis. The result is great thickening and the formation of a caseous mass, enclosed very often in a firm fibrous capsule. Thus a firm elongated tumour may form behind and partly surround the testicle (Fig. 706). In the testicle also caseous centres form, at first isolated, but afterwards running together into considerable masses. The caseous masses are very dense, but after a time they generally break down, and, having burst externally, troublesome fistulæ are the consequence.

When the testicle is examined in section the caseous structure is seen to be surrounded by a transparent grey tissue, in which tubercles are present. This inflammatory and tubercular structure by its pressure destroys the tubules for the most part, and portions of necrosed tubules are sometimes expelled along with the softened caseous material.

Tuberculosis of the testicle sometimes leads, after it has discharged externally, to a protrusion of the testicular tissue, constituting the so-called **Fungus testis** or **Hernia of the testis.** A similar result sometimes occurs in **Syphilis.** The dense tunica albuginea, when stretched by the new-formation, may force the tissue through the opening so that it protrudes externally. The protruded mass contains tubules, and is, in fact, the everted tissue of the testicle.

As previously mentioned, tuberculosis of the testis often extends along the vas deferens to the vesiculæ seminales, prostate, and bladder, and sometimes from the bladder to the ureters and kidney. There is a tuberculosis along this whole course, and not a mere conveyance of the bacillus along intact channels.

5. **Tumours of the testicle.**—These are mostly somewhat malignant in their characters, and there is a peculiar tendency to a mixed structure.

Enchondroma is not infrequent in the testicle. It is usually mixed with other forms, but it may occur pure. As the tissue here is heterologous it often shows malignancy. Thus it has been found growing into the lymphatics and blood-vessels around, and it forms secondary tumours in the lungs. For the rest, the occasional occurrence of fibromas, lipomas, myomas of the striated variety, and even osteomas, has been observed.

Cystic tumours.—The cystic tumours of the testicle show considerable analogies with those of the mamma and are capable of a somewhat similar division. The cysts in all cases originate in gland tissue, which is believed by some to be the regular seminal tubules, but, according to Eve, is rather the rudiments of the Wolffian body which are retained at the hilum of the testis. We have seen similar remains exist at the hilum of the ovary. The tumours originate chiefly at the hilum, and the tissue of the testis may be spread over them.

The tumours may be of considerable size, and present cysts of various shapes and sizes. The cysts are usually lined with cylindrical epithelium which is sometimes ciliated. The epithelium sometimes has the characteristic goblet form, such as that in the colloid ovarian cystoma.

The stroma varies greatly in structure. It may be fibrous, in which case the tumour may be called an **Adeno-fibroma** or a **Cystic-fibroma**, or it may be sarcomatous, in which case the term **Adeno-sarcoma** or **Cystic sarcoma** is used. In some cases it has the structure of mucous tissue, hence **Cystic myxoma**. It is not uncommon to find portions of cartilage in the stroma, and portions of striated and of smooth muscle have been found.

Dermoid cysts and **Teratomas** are also met with having a complex structure like those of the ovary and containing hairs and sebaceous matter. Recently structures resembling those met with in chorion-epithelioma have been found in certain tumours of the testis.

The spermatocele is also properly a cyst of the testicle, but it is considered below along with hydrocele.

Sarcomas occur frequently mixed with the tissue of other tumours, as the myxoma, enchondroma, etc. Even when the tumour is a pure sarcoma there may be combined the structures of various forms of this tumour, spindle cells, round cells, and mucous tissue. There may, however, be a simple round-celled sarcoma. The sarcomas generally form large tumours of soft consistence and rapid growth, and usually originate in the substance of the testicle. They occur in comparatively young persons, and are prone to metastasis, the secondary tumours occurring mainly in the lungs.

Cancer of the testicle connects itself with the cystic and adenoid sarcomas. It appears that not infrequently the glandular tissue in these tumours has more of the irregular atypic cancerous character than of the strictly glandular, and in particular the epithelial masses do not possess a membrana propria. These characters are also expressed in the fact that sometimes these tumours extend to the neighbouring lymphatic glands, while others penetrate more readily into the veins.

True cancer of the testis is usually a large quickly growing soft tumour—**Medullary cancer**. It involves the whole organ as well as the epididymis, converting them together into a massive tumour (see Fig. 707). It may also extend along the vas deferens, and to the lymphatic glands—inguinal, lumbar, and pre-vertebral. From these glands it may extend to the radicles of the portal vein and so produce tumours in the liver, or more frequently to the radicles of the vena cava, producing tumours in the lungs. In the midst of the tumour we may have cysts formed by mucous or fatty degeneration.

The cancerous tissue is derived from the epithelium of the seminal tubules, and the stroma from the interstitial tissue. In a case of cancer of the testicle in an infant the author found the interstitial tissue presenting the characters of mucous tissue. It is necessary to mention that tumours may arise in connection with the blood-vessels, which have a resemblance in their structure to cancers, but which are properly plexiform angio-sarcomas.

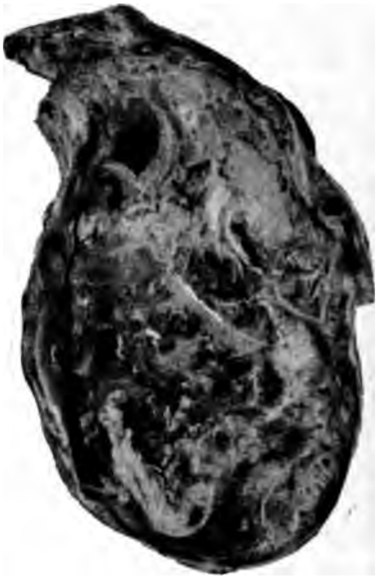

Fig. 707.—Cancer of the testicle.

6. **Hydrocele.**—By this name is meant the accumulation of fluid in the tunica vaginalis. The fluid is serous and the cause of its accumulation is believed by some to be inflammation. On the other hand the absence of pain and the infrequency of adhesion of the sac are in favour of a non-inflammatory origin, and the hydrocele may be the result of a local dropsy to which the dependent position of the sac predisposes. Cases of **Acute hydrocele** have been observed in which the disease is undoubtedly inflammatory, fibrine being deposited on the surface as well as fluid accumulated in the sac.

In ordinary **Chronic hydrocele** fluid slowly accumulates and distends the sac, and so a bulky tumour is formed which is pear-shaped with its blunt end downwards. The fluid is usually a clear serum with a specific gravity of 1022 to 1024, but sometimes it is slightly opalescent. In the true hydrocele this is not from the presence of spermatozoa, but from the existence of fine fat drops, resulting from degeneration of the leucocytes floating in the fluid. Cholestearine crystals may be formed in this way.

Not infrequently hæmorrhage occurs, most commonly as the result of a blow or other injury, and the hydrocele becomes a **Hæmatocele.** The blood usually coagulates, and the coagulum in time undergoes various changes, softening into a brown pultaceous material or into a brown turbid fluid, in which are enormous numbers of cholestearine crystals. The blood seems to act as an irritant to the tunica vaginalis, causing often a very great thickening of it. The interior also is rough and sometimes presents considerable projections. The thickened cyst may contract somewhat so that the tumour is reduced in size. This thickening of the wall, even when the contents are fluid, may cause the hæmatocele to be mistaken for a solid tumour, and castration has often been performed under this belief.

A hydrocele or hæmatocele may be cured by the fluid being absorbed, the result being adhesion of the opposed surfaces of the tunica vaginalis and obliteration of the sac.

In the condition named **Congenital hydrocele** the tunica vaginalis retains its communication with the peritoneal cavity. The fluid may come from the peritoneal cavity, or it may originate as in an ordinary hydrocele. It can be pressed back into the peritoneum through the neck. It will be understood that a congenital hernia may coincide or alternate with this form of hydrocele.

7. **Spermatocele. Encysted hydrocele.**—In this affection there is a cyst having in many cases much the external appearance of hydrocele, but containing a fluid in which spermatozoa are abundantly present. In other respects also the condition differs from that of hydrocele, for we have here not merely an accumulation in an existing sac, but a proper new-formed cyst. Hence the name Encysted Hydrocele is often used as equivalent to spermatocele. The cyst is most frequently single, but there may be many.

The cyst arises in connection with the epididymis for the most part, and probably takes origin in one or more aberrant tubules which form blind diverticula from the seminal tubules. It usually arises near the upper end of the epididymis, but it may occur at the lower end or may arise from the rete testis. The cysts often enlarge, and sometimes grow into the sac of the tunica vaginalis, pushing one layer of the wall against the other. As a rule, the tunica vaginalis is found below and in front of the cyst, this position being connected with the origin of the cyst in the neighbourhood of the epididymis.

The fluid from these cysts has a peculiar opalescent appearance, which is due to the presence of multitudes of lively spermatozoa. The existence of these shows that the cyst has retained its connection with the seminal tubules. The cyst is usually lined with ciliated epithelium, but in large ones the pressure of the fluid may cause these cells to assume the pavemented form.

It will be noted that the spermatic cysts are comparable in their origin to the parovarian cysts.

Other forms of hydrocele have been described, but they require only a passing notice. There may be an encysted hydrocele without spermatozoa in the fluid. Then there is encysted hydrocele of the cord, sometimes arising by a portion of the communication between the tunica vaginalis and the peritoneum remaining unobliterated and becoming the seat of an accumulation of fluid. There is also a diffused hydrocele of the cord, in which there is an œdematous condition of the connective tissue around the spermatic cord. There may even be a hydrocele arising from a hernial sac, which has become emptied of its contents and shut off from the peritoneum by adhesion of the neck.

8. **Some other affections of tunica vaginalis.**—**Free bodies** are not infrequently met with in the sac. The bodies are somewhat similar to those found in the sheaths of tendons and elsewhere. Their numbers vary in individual cases, but they have been found up to several thousands in one case.

Tuberculosis of the tunica vaginalis occurs by secondary extension from the testicle on the one hand and from the peritoneum on the other. The latter can only occur when the original communication between the tunica vaginalis and the peritoneal cavity remains open, as in congenital hernia, and a tubercular peritonitis happens to supervene. Cases of this kind are observed in children. The testicle is liable to be involved by further extension.

Tumours of the tunica vaginalis.—The principal form of tumour observed is the **Sarcoma**. The tumours are liable to grow round the testicle and compress it.

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B.—The Penis, Scrotum, Prostate, and Vesiculæ Seminales.

1. **The Penis.**—**Ulcers** or **Chancres** are the commonest forms of disease. The soft chancre is an ulcer which has its usual seat on the glans or frænum. (See further under Skin diseases.) The hard chancre is the primary syphilitic sore, and as such has already been described.

Another syphilitic manifestation is the **Condyloma**, which forms a warty outgrowth sometimes of considerable size. There may be large groups of papillæ forming a cauliflower-like tumour.

Gummata are very rare in the penis, but they do occur. They are stated to be in some cases the precursors of cancer.

Tuberculosis of the penis is rare, but cases are recorded in which the prepuce has become infected as a result of the rite of circumcision being performed by a person affected with tuberculosis of the lungs.

Cysts occasionally occur on the prepuce and raphé. They are often congenital.

Cancer of the penis occurs in the form of epithelioma. It begins usually in the glans, and the tumour is often covered with prominent papillæ, which give it a highly characteristic warty appearance, like the cauliflower excrescence. The papillæ are sometimes greatly elongated like villi, so as to appear almost filiform in appearance. The tumour may remain long without ulceration, but usually sooner or later breaks down, and there are sometimes deep ulcerating fissures or fistulæ between the groups of papillæ. In Fig. 708 the appearances met with in three cases of epithelioma of the penis are shown.

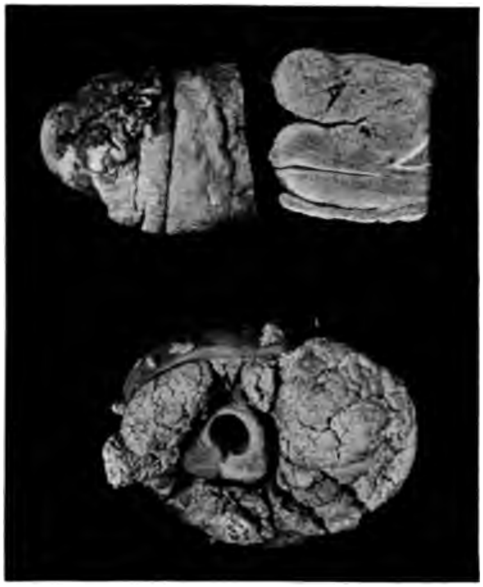

Fig. 708.—Epithelioma of the penis.

2. **The Scrotum.**—**Cancer** is somewhat common, and the disease is so frequent amongst chimney-sweepers that it is often called chimney-sweepers' cancer. In Glasgow it has been found that workers in paraffin refineries are also liable to this disease. It generally forms a flat tumour from the surface of which prominent papillæ protrude. In time ulceration occurs and the testicle may be exposed. Dark pigmentation of the skin is not infrequent around the cancer.

Elephantiasis of the scrotum is referred to and illustrated in the general part of the work.

Lymph scrotum has already been referred to in connection with the filaria sanguinis. In it there is a varicose condition of the lymphatic vessels of the scrotum with the formation of vesicles in the skin. These frequently burst and discharge fluid. In some cases the filaria is present in the blood. The lymphatic glands of the groin are indurated, and the dilatation of the lymphatics has been ascribed to the obstruction of these vessels in the glands by the embryo filariæ.

3. **The Prostate.**—A very important lesion of this structure is **Hypertrophy.** The common enlargement of old age is due chiefly to increase of the muscular substance. This enlargement exists in about 30 per cent. of men above 60 years of age. It develops slowly without any apparent cause, and in this respect has the characters of a tumour (see Fig. 669, p. 1124). Sometimes the prostate enlarges uniformly, and it may reach the size of the fist. But sometimes, with or without a general enlargement, there is a more local hypertrophy, forming the so-called third lobe of the prostate, which projects inwards at the neck of the bladder, and is sometimes so large as to act like a valve to the orifice of the urethra. This third lobe scarcely exists as a visible lobe when the normal prostate is examined after laying open the bladder, and when thus visible it is entirely a new-formation. The effect of enlargement of the prostate on the urethra is important. If there is a general enlargement the urethra is necessarily elongated in its prostatic portion, and whereas normally this portion measures 1½ inches in length it may come to be 4 inches. At the same time the tube may be narrowed and even distorted. If, for instance, the central part of the prostate part is specially hypertrophied, then the urethra, being pushed upwards, has on section a crescentic shape with the convexity upwards; or if one side is larger than the other, there will be a convexity towards the opposite side.

Besides this muscular hypertrophy the more unusual hypertrophy of the glandular structure is to be mentioned. The glandular structure may increase with the muscular, but sometimes it enlarges by itself, so that we have an **adenoma** of the prostate.

Cancer of the prostate is not of frequent occurrence. The gland enlarges and the disease is apt to extend to neighbouring structures. (Fig. 709.)

Tuberculosis occurs not infrequently in the prostate and vesiculæ seminales in conjunction with similar disease in other parts of the genito-urinary passages. There is caseous necrosis with ulceration as usual, and this may cause even perforation into the rectum or bladder.

Concretions are of very frequent occurrence in the prostate in old persons. They are formed in the gland-ducts and are of various sizes, up to the size of a grain of corn. When small they are colourless, but as they enlarge they frequently become blackish or reddish brown in colour. They are round or oval in form and frequently present concentric stratification. They have usually a central cavity. These bodies mostly present the character of amyloid bodies, giving a bluish or mahogany red colour with iodine, and the usual bright red colour with methylviolet (see under Amyloid Degeneration). Often they contain lime salts in their substance. They may pass into the urethra and escape with the urine. While in the prostate they do not as a rule produce much disturbance, but occasionally they are found in association with suppurative prostatitis. (Fig. 710.)

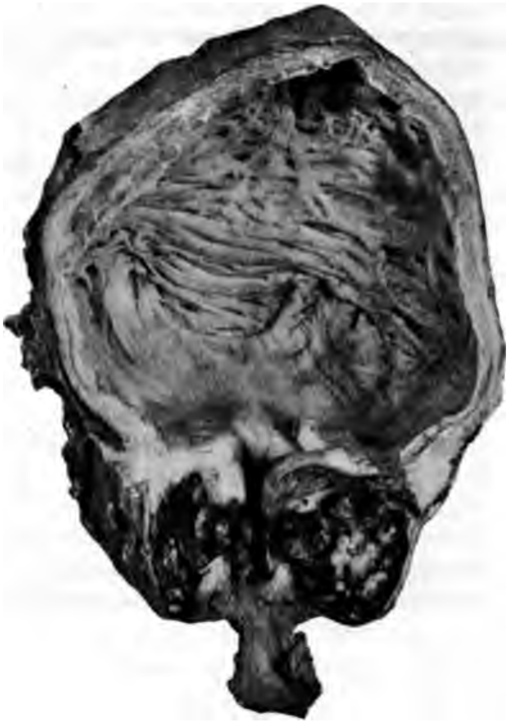

Fig. 709.—Cancer of the prostate.

4. **Spermatic cord and vesiculæ seminales.**—The spermatic cord, in the part of its course outside the inguinal canal, is liable to varicose dilatation of its veins constituting **Varicocele** (see under Affections

of Veins). There occurs also occasionally hæmorrhage into the cord constituting a hæmatoma.

Tuberculosis is a somewhat frequent disease in the cord and vesiculæ seminales. It arises by extension from the testicle. The disease may be unilateral and in the vesiculæ seminales it may lead to a very marked one-sided enlargement. There are the usual phenomena of thickening by new-formation of granulation tissue and tubercles and caseous necrosis. There may be also considerable ulceration with discharge of the products into the urethra. The tuberculosis may further extend to prostate, bladder, ureter, and kidney.

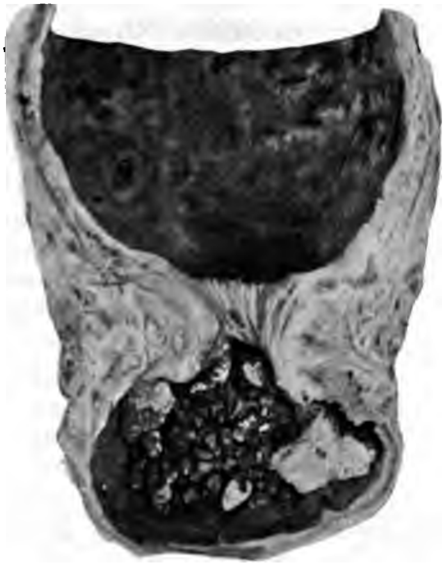

Fig. 710.—Prostatic calculi associated with suppurative prostatitis.

Concretions like those in the prostate are sometimes found in the vesiculæ seminales.

Literature.—*Penis*; *Gummata*—OZANNE, Rev. de la Chir., 1883. *Tuberculosis*—LEHMANN, Deutsch. med. Woch., 1886, Nos. 9-13; LOEWENSTEIN, Die Impftuberculose des Præput., 1889; KRASKE, Ziegler's Beiträge, x., 1891, p. 204. *Cysts*, (with literature), EDINGTON, Glas. Med. Journ., xlix., 1898.

SECTION XI.

DISEASES OF THE SKIN AND ITS APPENDAGES

Introduction, as to normal structure. I. **Hyperæmia, Hæmorrhage,** and **Œdema** including **Angioneuroses.** II. **Retrograde changes.** 1. Atrophies of skin, hair, and pigment ; 2. Pigmentations ; 3. Necrosis, including ulcers. III. **Inflammations.** Causation. 1. Inflammatory skin eruptions, the individual lesions and different forms ; (*a*) Sudamina, (*b*) Erythema and Roseola. (*c*) Eczema, (*d*) Psoriasis, (*e*) Pityriasis rubra, (*f*) Lichen ruber, (*g*) Prurigo, (*h*) Pemphigus, (*i*) Acne. 2. Symptomatic Inflammations, in acute fevers, chiefly small-pox. 3. Inflammations from heat, cold, and injury. (*a*) Burns and scalds, in three degrees, (*b*) Frost-bite and chilblain, (*c*) Wounds and excoriations. 4. Infective inflammations. (*a*) Boil and carbuncle, (*b*) Cadaveric infection, (*c*) Phlegmonous inflammation, (*d*) Soft chancre, (*e*) Malignant œdema, (*f*) Anthrax, (*g*) Hospital gangrene. IV. **Specific new-formations.** 1. Syphilis, in primary, secondary, and tertiary forms ; 2. Tuberculosis, as Lupus, Scrofuloderma, and Pathological Wart ; 3. Leprosy; 4. Elephantiasis ; 5. Granuloma fungoides ; 6. Frambœsia. V. **Tropho-neuroses.** Causation. 1. From nerve-leprosy ; 2. From nerve-syphilis ; 3. Herpes ; 4. Glossy skin ; 5. Scleroderma and Morphœa. VI. **Hypertrophies and tumours.** 1. Ichthyosis, 2. Corn, 3. Wart, 4. Soft wart or mole, 5. Angioma, 6. Keloid, 7. Molluscum contagiosum, 8. Fibroma molluscum, 9. Xanthoma, 10. Simple tumours, 11. Xeroderma pigmentosum, 12. Sarcoma, 13. Cancer. VII. **Parasitic affections,** chiefly from fungi. 1. Favus, 2. Ringworm, 3. Pityriasis versicolor, 4. Animal parasites.

INTRODUCTION.

THE diseases of the skin are exceedingly manifold, and their nomenclature is somewhat complicated. In this section an endeavour is made to summarize the pathological conditions and group together the various diseases according to the nature of the lesion.

Normal structure.—The **Corium** or **True skin** is a very vascular dense membrane composed of interlacing fibres of connective tissue, with numerous elastic fibres. It is richly supplied with nerves, and possesses bundles of smooth muscle. It has also a rich system of lymphatic vessels. In the corium we may distinguish a superficial or **Papillary layer** and a deeper one. Many of the diseases affect the papillary layer especially.

The **Epidermis** on the surface of the corium is in several layers. Most superficial is the horny layer composed of flat cells, which are little more than scales, and have lost their nuclei. Next comes the stratum lucidum, composed of flat transparent cells. Most deeply situated is the stratum mucosum or rete Malpighii, composed of cells which, in the deepest layer, are cylindrical, but towards the surface become polygonal and flattened. In the deeper layers the cells are serrated at the margins, so as to give the appearance of prickles by which the cells fit into each other. The Malpighian layer extends between the papillæ of the corium, forming interpapillary processes.

The **Sebaceous glands** may be regarded as modified prolongations of the Malpighian layer. They are mostly connected with hair follicles into which they open, but sometimes large glands are connected with small hairs and small glands with large hairs, while there are glands not connected with hairs at all. The **Sudoriparous glands** are usually situated beneath the skin, their ducts passing through corium and epidermis, having a spiral course in the latter. The **Hairs** are composed of horny epidermis, and are placed in follicles. In the latter, two layers of epidermis can be distinguished, the outer root-sheath corresponding with the Malpighian layer, and the inner root-sheath corresponding with the horny layer. At the bottom of the follicle is a papilla continuous with the corium, and on this is set the bulb of the hair. The **Nails** are composed of compressed horny epidermis. Beneath the nail are still two layers of epidermis, a horny layer of loose cells, and a Malpighian layer covering well-formed papillæ.

The exposed position of the skin renders it very liable to the influence of agents acting from without. It is also liable to be influenced by irritants circulating in the blood, in which case the skin affection will probably be an insignificant part of a general condition. The skin again is liable to be affected by states of the nervous system. From these remarks it will be inferred that the inflammations of the skin are its most important morbid conditions, and will call most largely for description.

The skin, like other structures, and more obviously because of its visibility, presents great differences in structural detail in different individuals. These are variations in pigmentation, fineness of texture, vascularity, elasticity, etc., which form parts of the individual constitution of the person. One of the most striking variations is an extreme elasticity of the skin presented by some individuals, so that it can be laid hold of and drawn outwards from the underlying parts. Of similar constitutional significance are the varying susceptibilities to morbid influences which different individuals present. This is exemplified in many forms of disease of the skin.

Literature.—*General works*—Erasmus Wilson, Dis. of skin, 1867; Neumann (Pathological anatomy is very good), Lehrb. d. Hautkrank., 1880; Hebra and Kaposi, Dis. of skin (Syd. Soc.), 1866-1880; Duhring (literature very complete), Dis. of skin, 1882; Ziemssen, Handbook of Dis. of skin, 1885; Kaposi, Hautkrankheiten, 1893; M'Call Anderson, Dis. of skin, last edition; Path. very fully in Unna, Die Histopathologie der Hautkrankheiten (part of Orth's Path. Anat.), 1894; also in Atlas by Leloir and Vidal, the plates of which give histology of skin diseases with great accuracy; Radcliffe-Crocker, Diseases of the skin, latest edit.

I.—HYPERÆMIA, HÆMORRHAGE, ŒDEMA OF THE SKIN.

The skin is very liable to variations in its blood supply. An active **Hyperæmia** hardly occurs as a pathological condition except as part of an inflammation. Passive hyperæmia, on the other hand, is exceedingly common as a result of general venous engorgement, especially in disease of the heart. From the blue colour assumed by the skin in passive hyperæmia the condition is designated **Cyanosis.**

Local variations in the circulation also occur by stimulation of the vaso-motor nerves, the resulting conditions being named **Angioneuroses.** These imply an excessive irritability of the vaso-motor nerves of the skin, and a proclivity on slight stimulation to contraction chiefly of the arteries, but also of the veins. The most exaggerated example of this is afforded by **Raynaud's disease,** where from insignificant external causes spasms of arteries and sometimes of veins come about. If both arteries and veins are contracted then there is anæmia of the part (a condition called by Raynaud *local syncope*), whilst if only the arteries are contracted there is a passive hyperæmia or cyanosis (called by Raynaud *local asphyxia*). In either case necrosis may occur, taking the form of **Symmetrical Gangrene.** Short of these extreme cases we find, in persons whose vaso-motor nerves are sensitive, that exposure to cold leads to a local syncope. On the other hand, in persons in health, the arteries alone contract, and cold produces a cyanosis or blueness of the skin.

Besides these more direct examples of angioneuroses there are **Local œdemas** and other lesions which are related to the vaso-motor nerves, but not in such a simple fashion. **Urticaria** is a local œdema or accumulation of fluid in the lymphatics of the corium, resulting in limited swellings. It always implies an abnormal sensitiveness of the vessels. Thus in many persons a flea-bite induces a local œdema, characterized by the wheals or quaddels of urticaria. In others the stroking of the skin with the edge of the nail or a pencil causes ridges of œdema to rise so that words can be produced in raised letters (Urticaria factitia). But this special sensitiveness may be induced either by irritants in the blood or by reflex irritation. Thus a more or less generalized urticaria is brought about in some persons by eating shell-fish or certain other kinds of food. In these, however, there is, as in urticaria factitia, always a local irritation as well as a general sensitiveness, as is proved by the fact that the urticaria develops on parts which are exposed to friction, either of the clothes or otherwise. There is thus a gradation in these lesions towards inflammation.

This applies even more to those eruptions which Unna has included along with general urticaria under the name of **Erythanthema,** in which the exudation of fluid leads to elevation of the cuticle and the formation of vesicles and bullæ.

Hæmorrhages are frequent and of various kinds. They arise by traumatic rupture of its vessels, but still more, perhaps, by alterations in the state of the blood affecting its vessels. In scurvy, in purpura, in small-pox, in typhus, etc., the skin is the seat of hæmorrhages much more frequently than any other part.

The blood escaping from the vessels collects in the serous spaces of the corium for the most part, but may pass to the subcutaneous tissue, where the fat is sometimes considerably infiltrated. When the blood has escaped from a small vessel and infiltrates a limited area so that a bluish spot is seen on viewing the surface, the term **Petechia** is given. As these small hæmorrhages depend on the state of the blood, the petechiæ are nearly always multiple. When the blood infiltrates a larger area then the term **Ecchymosis** is used. Sometimes the blood collects between the corium and epidermis, and then a hæmorrhagic **Vesicle** is the result; but this can only happen if the deeper layers of the epidermis have been killed so as to allow of their separation from the corium. When there are numerous small hæmorrhages forming a large number of petechiæ, then it is customary to use the term **Purpura,** or to speak of a purpuric condition.

The blood effused in the skin undergoes changes like those already described (see Hæmorrhage). The affected area is first dark blue, and the colour does not disappear on pressure. After a time, as the blood-colouring matter is dissolved, the colour becomes fainter and changes in hue, while the discoloration becomes more extended. If blood has collected between the layers of epidermis, it comes to the surface and is disposed of as the epidermis is shed.

General œdema of the skin, apart from inflammation, is chiefly related to diseases of the heart and of the kidneys. Its general pathology has been already considered. The exuded fluid collects in the lymph spaces and is carried off by the lymphatics. **Myxœdema** has also been described.

II.—RETROGRADE CHANGES IN THE SKIN.

1. **Atrophies.—Simple atrophy** is not uncommon in the skin. The most frequent example of it is afforded by **Senile atrophy**, resulting in the wrinkled skin of old people. In this case the connective tissue of the cutis loses in bulk, especially the papillary layer. The epidermis is also thinner and drier, and there is often desquamation in the form of dry scales or larger membranous pieces. The hairs are atrophied, as their papillæ have taken part in the general atrophy of the papillæ of the skin. The hair-follicles are shortened, and the sebaceous glands on this account may be brought close to the surface so as to be very visible in the thin skin.

A general atrophy also occurs in emaciated persons, and it may closely resemble the condition in senile atrophy.

Of the **Local atrophies** the most familiar is that which occurs after **Pregnancy**. White lines are found in the abdomens of women who have been pregnant, and similar lines occur in persons whose abdomens have been distended by tumours, by ascites, or even by accumulation of fat. The white lines have a cicatricial appearance, and they seem to owe their origin to the connective-tissue fibres of the cutis having dissociated by the stretching. Somewhat similar white lines or striæ sometimes occur idiopathically, especially over the buttocks, trochanters, pelvis and thighs.

The **Hairs** are liable to atrophy, and two forms may be distinguished according as either the hair itself or the pigment diminishes. **Alopecia** or **Baldness** is atrophy of the hair itself. All through life a continuous falling out of the hair is occurring, and is due to atrophy of the bulb. But the papilla remains, and a healthy new hair is produced on the site of the old one. In some people as life advances the new hairs are not reproduced of normal size, and they become gradually finer and finer, till there are only the finest silky hairs on the bald part, or even none at all.

Besides being produced in this way, baldness may be **secondary** to syphilis, to inflammations, and to certain parasitic diseases; in these cases it depends on interference with the nutrition of the sheath and papilla.

Special attention has been paid to **Alopecia areata**, in which baldness occurs in circular patches. These patches are not entirely bald, but are covered with fine woolly hairs, and the papillæ are not destroyed.

The nature of this disease is obscure, some regarding it as parasitic, and others as a trophoneurosis. Its habit and mode of extension render the parasitic view very probable. Thin contends the parasite here is a micrococcus, which is much more difficult to detect than the other parasites of the skin, which are fungi, and more recently Sabouraud has described a minute bacillus which he regards as the cause of the disease.

Canities or Greyness of the hair is also for the most part a natural atrophy of advancing life. But it also sometimes comes on prematurely. It depends for the most part on a deficiency of pigment in the individual hairs at their original formation, so that the pigment granules in the cells in the cortical layers of the hair are diminished. But there may be a temporary blanching of the hair from air getting infiltrated among the cells of the cortex. Cases of sudden permanent blanching have received no satisfactory explanation.

Albinism is a congenital absence of pigment which affects the iris and choroid of the eye as well as the hair and skin. It is not infrequent in negroes, the peculiar result being a white negro. The albinism is sometimes partial, so that, in the case of the negro, a piebald appearance is produced.

The **Nails** are liable to atrophy. This may be congenital or acquired. In the course of acute illnesses, such as fevers or maniacal attacks, the formation of the nails is often partially suspended, and the illness is marked for a time by a transverse depression, which, with the growth of the nail proceeds from the root outwards, and disappears in due course. The nails also atrophy sometimes in consequence of various parasitic or inflammatory skin diseases.

2. **Pigmentations.**—Two fundamentally different forms of pigmentation of the skin are distinguishable, according as the pigment arises by intracellular metabolism or is directly derived from the blood-pigment. The latter occurs in cases of hæmorrhage or of prolonged hyperæmia, as in the neighbourhood of varicose ulcers and in the cicatrices after the healing of these.

Of more importance is the true **Melanotic pigmentation**. This is illustrated in **Addison's disease** (see under Intoxications), where there is a bronzing of the skin chiefly in the exposed parts. The pigment here is in the deeper layers of the epidermis and more superficial layers of the cutis. **Syphilis** is also a cause of pigmentation. Most chronic syphilitic lesions of the skin are accompanied by and leave behind a coppery coloration.

Chloasma is a local pigmentation of the skin which has mostly a reflex origin. It occurs chiefly during pregnancy, brown coloration of the face developing pathologically as brown coloration of the nipple and areola develop physiologically. The name is also applied to deepening of colour in cachectic persons.

Argyria or coloration with silver is an occasional result of the internal administration of salts of silver. The coloration occurs chiefly in parts exposed to light, and it is apparently due to the reduction of the silver salt and its deposition in a finely granular form. The silver, as regards the skin, is confined to the cutis vera, where it is in the connective tissue, more especially in the elastic fibre and more dense membranous parts. The affected persons have a peculiar slaty-blue colour. A local argyria has been observed in persons whose occupations exposed them to the dust of silver.

Xeroderma pigmentosum is considered further on under tumours.

3. **Necrosis.**—Death of portions of the skin occurs under various circumstances. Perhaps the commonest case is that of **Bedsores** (*Decubitus*), in which a piece of skin which has been exposed to pressure whilst lying, dies and is discharged as a slough. This occurs chiefly in weak and debilitated persons. It is met with frequently in insane persons and paralytics, and it is matter of controversy how far an affection of trophic nerves may have to do with the necrosis (see under Necrosis).

In all forms of **Cutaneous ulcers** there is necrosis, which may be in the molecular or in a more material form. The margin of the ulcer is inflamed and infiltrated with inflammatory products. Enlargement takes place by a gradual necrosis of the inflamed structures, and generally implies the continuous action of an irritant. The irritant is mostly an infective virus, and the majority of the ulcers will be again referred to under subsequent headings.

In the case of such **Infective ulcers** there is usually a granulating surface which is gradually destroyed by the action of the virus. When the virus has been destroyed, the ulcer proceeds to heal like a granulating wound.

The **Varicose ulcer**, arising in connection with varicose veins, owes its origin to a prolonged venous hyperæmia, leading to œdema and infiltration of the skin. The nutrition of the skin is seriously compromised, and a trivial external injury may cause the epidermis to give way. The exposed and inflamed skin forms granulations, but these also, from the persistent venous engorgement, are readily destroyed by slight injuries, and the ulcer advances, while the inflammatory infiltration of the skin outside extends. The granulations will only proceed to heal in the usual way when the venous hyperæmia is removed.

The **Perforating ulcer of the foot** is a peculiar form which is believed by some to be due to a trophic lesion of the nerves. There have been found in some cases inflammatory lesions of the nerves, and the disease is sometimes associated with nervous affections, especially locomotor ataxia and more rarely with diabetes. It is questionable how far mere anæsthesia is sufficient to account for the formation of the ulcer, as seems to be the case in anæsthetic leprosy. The ulcer is characterised by the formation of an aperture on the surface of the foot, which leads to penetrating sinuses in its substance, and often attacking the bones.

III.—INFLAMMATIONS OF THE SKIN.

These include a very great variety of diseases, and the nomenclature is exceedingly complicated. In the skin, as elsewhere, inflammation is produced by the action of irritants; the form of the inflammation will depend greatly on the nature and source of the irritant.

Causation.—In some cases the origin and mode of action of the irritant is perfectly obvious, while in others it is very obscure. We have, for instance, septic inflammations, as in erysipelas, due to a definite microbe. We have also the various inflammations in connection with the acute fevers in which a specific morbid poison attacks the skin. But there are other cases in which the origin is less evident, and in which the peculiarities of the individual constitution play an important part. Just as there are persons specially liable to inflammations of the bronchi, of the kidneys, or of the intestine, so there are persons whose skin is prone to inflammation. Even in persons not predisposed temporary states of the nervous system apparently lead at times to a special tendency. At such times a very slight external irritation will lead to an inflammatory manifestation. There are indeed cases in which the nervous condition is the only obvious cause, as seen in a mild form in Urticaria, and in a more pronounced form in the so-called Trophoneuroses.

In considering the various forms of inflammation of the skin we shall divide them into four groups on the basis of their causation. These are (1) Inflammatory skin eruptions; (2) Symptomatic cutaneous inflammations; (3) Inflammations from heat, cold, and injury; (4) Septic and infective inflammations.

1. **Inflammatory skin eruptions.**—The affections included under this designation consist in various inflammatory affections of the skin due in some cases to local irritation, and in others to general irritation from conditions of the blood. In most of them individual peculiarities play a very important part, so that slight irritations which have no effect in

some people produce eruptions in others. Indeed the tendency in many cases is so great that the conditions are regarded as idiopathic. There is no doubt also that nervous conditions have an important influence. The beginning of a skin eruption is often accompanied by itching, and the scratching which the itching induces not infrequently assists in the development of the eruption.

Character of the lesions.—The inflammatory process occurring in the various structures of the skin produces the changes which occur elsewhere under like circumstances. There is hyperæmia, exudation of serous fluid and leucocytes, parenchymatous changes chiefly in the epidermis, and, if the inflammation be prolonged, new-formation in the true skin. Various names are applied to the anatomical conditions thus brought about.

A **Wheal** is a limited swelling of the skin due to an œdema of the superficial layers of the cutis. It is temporary, and in all cases the nervous system is concerned, as evidenced by the itching which is usually characteristic. A **Papule** is a small solid elevation of the skin, due generally to inflammatory exudation which infiltrates the papillary layer of the cutis and the epidermis. There is often proliferation of the epidermic cells as well. The term **Tubercle** is sometimes used, not in the histological sense, but to indicate an irregular rounded solid elevation from infiltration of the skin. In the **Vesicle** we have an accumulation of serous exudation raising the epidermis. The fluid is not between the cutis and epidermis, but the separation takes place amongst the softer cells of the Malpighian layer, so that there is epidermis both below and above the fluid. The vesicles may be very small or so large as to form considerable **Blebs** or **Bullæ**. A **Pustule** is like a vesicle but contains pus, and is due to a more intense inflammation. **Scales** or **Squamæ** are composed of epidermis which has been produced in excess and is less firmly attached than normally. The rapid production of epidermic cells is due to a parenchymatous inflammation, and the epidermic cells do not undergo the horny transformation to the same extent as normally.

The individual skin affections have received various names which only in part represent their pathological characters.

(*a*) **Sudamina or Miliaria.**—In this there are multitudes of minute vesicles, which are at first filled with clear fluid (miliaria crystallina) which afterwards may become turbid. The condition arises in cases where there is excessive sweating and more particularly in acute rheumatism. The vesicles originate in the terminal parts of the sweat-ducts. In a case examined by the author the cause of dilatation was the obstruction of the spiral part of the duct by leucocytes (see

Fig. 711), this narrow twisted part of the duct being incapable of giving passage to these cells. The disease was thus inflammatory from the outset, and its inflammatory nature was further proclaimed by the increasing accumulation of leucocytes as the vesicle increased (see Fig. 712). This was in a case of acute rheumatism, where presumably the irritant in the blood, in being secreted in the sweat, was the cause of the cutaneous affection. In cases where, from excessive sweating, there is an eruption of sudamina, there is probably an irritant in the sweat which may be less of a general pathogenic agent than that of acute rheumatism.

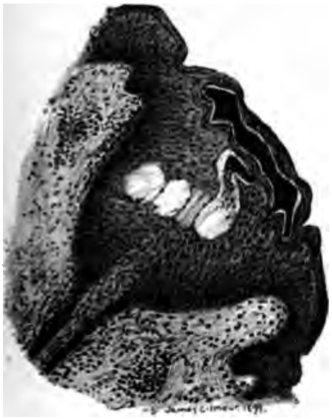

Fig. 711.—First stage in the formation of a sudamen. The terminal part of the sweat-duct is obstructed, and distension is beginning in the portion of the duct in the deeper layers of the epidermis. × 100.

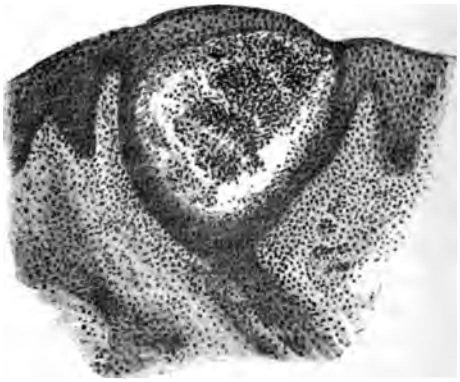

Fig. 712.—Sudamen formed by dilated sweat-duct. It is largely occupied by leucocytes attracted thither. × 80.

(*b*) **Erythema and Roseola.**—These names are applied to mild inflammatory conditions in which the chief, and sometimes the only apparent change is hyperæmia. The inflammatory nature of the condition is, however, often indicated by the existence of more or less swelling, due to œdema of the superficial layers of the skin (erythema nodosum and papulosum). The attacks are often followed by desquamation.

These very mild inflammations are frequently somewhat generalized, and appear in many cases to be, like urticaria, related to special conditions of the nervous system, especially perhaps, of the vaso-motor nerves. They may also be produced by external irritants, especially in susceptible persons.

(*c*) **Eczema.**—This name is applied to localized inflammations of the skin, usually of a sub-acute or chronic character. The mere fact of the local nature would indicate that the irritant here comes from without; but external irritation is hardly ever the entire explanation of the attacks. In no other disease do individual peculiarities and special states of the organism play a more important part. The external irritant may be very various, such as medicinal ointments, stuffs used by the patient in his occupation, as in dyeing, parasites which induce scratching, etc. The intensity of the inflammation depends on the susceptibility of the patient and the character of the irritant. The various degrees of intensity are, to a great extent, distinguished by the characters of the eruption, so that we have papules, vesicles, pustules, etc., characterizing different cases of eczema. From these differences are derived the names **Eczema papulosum, vesiculosum,** and **pustulosum.**

In chronic cases a condition is brought about somewhat comparable to catarrh of mucous membranes, and sometimes called **Catarrh** of the skin. The inflamed surface keeps on discharging serous fluid in varying quantity. The epidermis is softened, and, to a considerable extent, lost, so that the cutis is exposed or covered with irregular crusts. The cutis itself is red, and it is thickened both by the serous exudation and by accumulation of round cells.

(*d*) **Psoriasis.**—The nature of the irritant in this case is quite unknown, but it is probably to be found in some special condition of the blood. We know, at least, that remedies introduced into the blood frequently cure the disease.

The lesion is mainly of the epidermis, and especially of its Malpighian layer. The papillary layer of the cutis is hyperæmic and partly infiltrated with leucocytes; the papillæ are also described as enlarged, but these alterations are comparatively trifling, as, after death, very little indication of them is to be found. During life the hyperæmia gives the corium a red colour. In the middle regions of the Malpighian layer of the epidermis there is an abundant new-formation of epidermic cells. The new-formation is so great that there is no time for the cells to become horny before they pass to the surface. Hence the epidermis on the patch is entirely composed of Malpighian layer, and these cells, being soft, as they dry adhere much more readily into considerable scales than do the horny cells. For a similar reason, as they dry they shrink much more than the horny cells, and air insinuates itself into interstices between them. It is the finely divided air which gives the scales the peculiar silvery appearance characteristic of this disease (Rindfleisch). When the scales are removed the papillary layer of the skin is seen to be red and bleeds readily.

(*e*) **Pityriasis rubra.**—In this disease we have a more or less general affection, and it is not improbable that it depends on a lesion of the trophic centres of the skin. It is characterized by an excessive discharge of scales consisting of masses of epidermic cells. These scales pass off from slightly raised and reddened surfaces. In the earlier periods the cutis presents little more than hyperæmia with excess of leucocytes in its papillary layer, but when the disease has lasted for some time there is thinning of it with flattening of the papillæ. The sebaceous glands and hairs, as well as the sweat glands, are usually atrophied. There is often a very excessive discharge of epidermis; a small basket-full may sometimes be gathered daily from the bed of the patient. There is a form of this disease designated **Pityriasis rubra pilaris** in which the excessive production of epidermic cells is concentrated in and around the hair follicles. There is here also hyperæmia and cellular proliferation in the cutis. (See case by Morton, with microscopic examination by author, in *Brit. Jour. of Dermat.*, VIII., 1896.)

(*f*) **Lichen ruber.**—This is a diffused papular eruption, depending on some obscure general cause. There are individual red flattened papules on a red basis. As the disease goes on the skin becomes infiltrated and thickened, so that the movements of the joints are hindered, and fissures are formed at the folds of the skin. The nails are usually thickened. The disease seems to consist in an inflammatory infiltration of the papillary layer of the cutis and the Malpighian layer of the epidermis. The cells of the rete Malpighii are enlarged and increased in number, and the interpapillary processes are enlarged. The papillæ show abundant accumulation of round cells, especially around the vessels. There is often accumulation of epidermic cells in the hair-follicles.

(*g*) **Prurigo.**—This also is a diffuse affection of the skin, which somewhat resembles urticaria, but is more permanent. Like urticaria it seems to depend on some condition of the nervous system induced, especially among children, by neglect of sanitary conditions and defective nutrition. Numerous small papules which are intensely itchy appear on the skin. The papules are due to an inflammatory thickening of the papillæ and rete Malpighii. Round cells and serous fluid are exuded, so that when the head of the papule is removed by scratching a drop of fluid appears. By scratching the papules are often caused to bleed, and it is probably from this that they frequently leave a brown stain. The irritation produced by scratching may also lead to eczema.

(*h*) **Pemphigus.**—This condition is characterized by the formation of large vesicles or bullæ, filled with fluid, which is at first clear, but usually becomes more or less purulent. As the bullæ usually occur at intervals over a considerable surface, the disease is to be ascribed to some general cause, and in some acute cases the existence of an irritant in the blood is suspected. There is not here, as in small-pox, an exudation among the cells of the Malpighian layer, but for the most part the epidermis is raised as a whole; and the bleb is not divided by septa into loculi. If the bleb remain unruptured a layer of epidermis forms on the surface of the cutis. But if it burst, then the exposed cutis discharges for a time; by and by, however, a crust forms, under which the epidermis grows. In some cases the blebs are imperfectly formed and neighbouring ones coalesce, so that a considerable surface is affected. When these blebs burst there is little tendency to new-formation of epidermis, and the skin continues discharging fluid as well as crusts produced by the fluid drying in. This form is designated **Pemphigus foliaceus.**

(*i*) **Acne.**—This name is applied to inflammation of the sebaceous glands and their neighbourhood, chiefly in connection with accumulation of the secretion in the gland. There are two conditions, named respectively comedo and milium, in which sebum accumulates in the glands; it is chiefly in connection with the former that acne occurs.

In **Comedo** a sebaceous follicle is filled with secretion, which forms a solid plug in the gland. The end of the plug presents at the surface, and has a black or dark blue colour. The plug consists of shed epidermis and sebum, with occasionally a small parasite, the acarus folliculorum.

In **Milium** there is an accumulation of the secretion with closure of the orifice of the gland. The accumulated secretion forms a rounded solid globe, which can be felt in the substance of the skin, but over which the epidermis passes unbroken. It is, in fact, a small retention cyst, and it contains the secretion of the gland mixed with epidermis, so that on cutting into it a whitish globular body is discharged. The contents not infrequently become impregnated with lime (Fig. 713). The cause of the closure of the duct is obscure.

In **Acne** there is a more or less acute inflammation of the sebaceous glands, usually in connection with comedo. There is redness and swelling around, and pus is usually formed, and mingles with the substance of the comedo. Sometimes there is not a proper suppuration, but the substance of the plug is softened by the inflammatory exudation. The inflammation is due to the irritation of the plug, especially when by long stagnation it has become foul.

The name **Acne mentagra,** or **Sycosis,** is given to cases where there is inflammation of the sebaceous glands in connection with the hairs of the beard. There is a sycosis of parasitic origin, but in the simple form there is suppuration in and around the hair follicles of the nature of acne.

A more chronic inflammation of the sebaceous glands of the face, with special hyperæmia of the vessels around, has received the name **Acne Rosacea.** There is very little tendency to suppuration, but great thickening of the skin occurs, so that sometimes there are large lobulated and red protuberances, especially on the nose, on the surface of which many comedones are seen (see under Lipoma nasi).

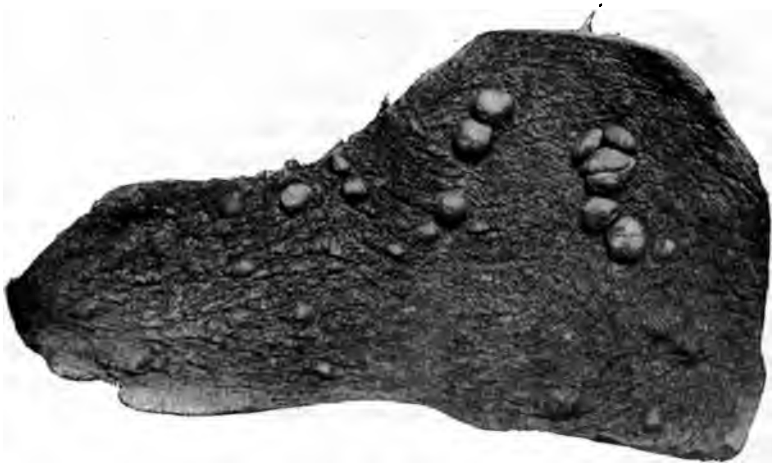

Fig. 713.—Milium of scrotum.

2. **Symptomatic inflammations.**—This class embraces the inflammations occurring in the acute fevers. In some the cutaneous affection is very trivial. Thus the eruptions in measles, scarlatina, typhoid and typhus fevers, consist of little more than inflammatory hyperæmia with slight exudation, with also, in severe cases of typhus, hæmorrhages, forming petechiæ. The action of the irritant on the epidermis is evidenced in many cases by the subsequent occurrence of desquamation, which implies that the cells have been so injured as to lead to their premature necrosis and discharge. This occurs especially in scarlet fever and measles.

In **Small-pox** there is a much more severe inflammation. In this case the virus, which is present in the exudation or so-called lymph, evidently lodges in the skin and multiplies there, leading to pronounced local changes (see p. 163).

The effects of the irritant are seen mainly in the epidermis, which shows changes chiefly in the more plastic Malpighian layer. Many of the cells undergo a kind of coagulation-necrosis, their nuclei being lost and their substance converted into a hyaline material. These necrosed epidermic cells allow of spaces being formed among their layers in which exuded fluid collects. In this way a vesicle is formed, but it does not consist of a single cavity. As shown in Fig. 714, the epidermic cells or their remains form a network of fibres and partitions which divide the vesicle into compartments or loculi (*b* in figure) in which a serous fluid, containing the micrococci, is present. As the inflammation increases in intensity leucocytes are exuded, and these accumulate, as seen in the figure, both in the superficial layers of the cutis (*d*) and in the loculi of the vesicle. By the aggregation of these the vesicle becomes a pustule. In the figure it is seen that while the papillary layer of the skin (*d*) is somewhat infiltrated with leucocytes, yet it is not destroyed, and the interpapillary processes of the Malpighian layer of the epidermis (*c*) still persist. Sometimes no further destruction occurs than this; the pustule dries in and a crust is formed, and under it the Malpighian layer forms new epidermis, so that when the crust is shed healing occurs without any loss of substance. But more commonly the action of the virus causes death of the superficial layers of the cutis as well as of the epidermis. This is shown in Fig. 715, where an injection thrown into the arteries runs into the surround-

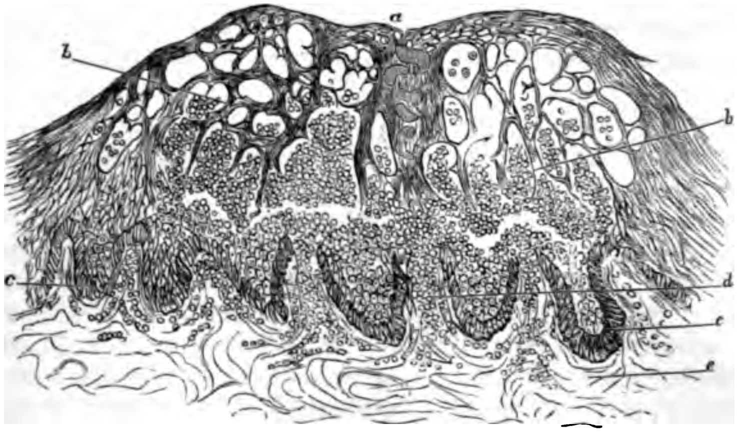

Fig. 714.—Section of a small-pox vesicle. Superficially there is a network formed of the altered epidermis. In some of the meshes (*b*, *b*) are pus corpuscles. For the most part the Malpighian layer in its deepest cells (*c*) is preserved, but at some points, as at *d*, it is broken through and the pus is infiltrating the skin. *a*, umbilication of the vesicle, due to a sweat gland, the coils of which are distinguishable × 140. (After RINDFLEISCH.)

ing skin (*a*, *a*), but does not penetrate into the slough (*b*). In this case, when the crusts are torn, little sloughs infiltrated with pus are revealed, on the removal of which ulcers appear. By the healing of the flat ulcers we have the depressed reticulated cicatrices characteristic of small-pox (the so-called pitting of small-pox).

Vaccination produces a lesion identical in its anatomical characters with that of small-pox.

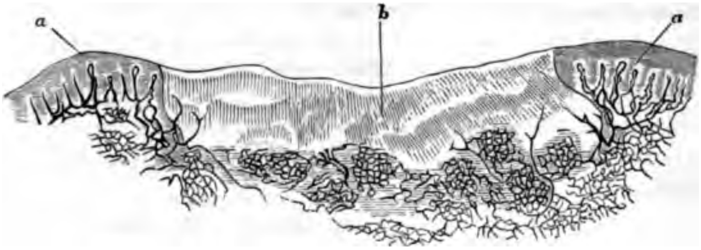

Fig. 715.—Small-pox eruption with necrosis, from an injected specimen. The normal skin at either side (*a*, *a*) has its vessels fully injected, while the necrosed part (*b*) is uninjected and homogeneous. × 50. (Rindfleisch.)

3. **Inflammations from heat, cold, and injury.**—(*a*) **Burns and scalds.**—We include here the lesions produced by the application of excessive heat to the skin, whether the heated substance applied be in the solid, liquid, or gaseous form. The heat acting as an irritant damages or kills the tissue, and so we have signs of inflammation, frequently associated with necrosis.

Burns have been classified, according to their intensity, into three degrees, characterized by the three phenomena—hyperæmia, vesication, sloughing.

In the **First degree** the heat is only sufficient to produce a hyperæmia of the skin. Exposure to the rays of the sun, or to hot water of a temperature of 100° F., and upwards, causes such a relaxation of the arteries as to induce considerable congestion. The inflammatory nature of this hyperæmia is shown by its continuance for some time after removal of the cause, and by the occasional occurrence of some œdematous swelling of the skin. After a time there may be desquamation.

The **Second degree** is produced by the action of a temperature of 140° to 185° F., or by the evanescent action of a still higher temperature. The effect is to cause an inflammatory exudation from the papillary layer of the skin, which accumulates in the epidermis so as to form a vesicle. The changes in the rete Malpighii are similar to those already described as occurring in the formation of the small-pox vesicle, but they are more rapidly produced and the layer of cells is more homogeneously affected. The inflammation soon subsides, and from the remaining cells of the rete Malpighii new epidermis is reproduced; there may be already a complete coating of new epidermis before the vesicle bursts. But sometimes the vesicle bursts early, and the inflamed surface of the skin is exposed; or nearly the whole of the rete Malpighii may have been destroyed, even the interpapillary processes. In these cases the covering-over of the surface with epidermis may be delayed, and the surface may even become like a granulating wound, discharging pus.

In the **Third degree** there is necrosis not only of the epidermis but of the true skin. The temperature is over 140° F., and if very high may have acted for a very short time. As a general rule the necrosed tissue lies as a dry crust on the surface. An inflammatory process occurs around it, with exudation, going on usually to suppuration. In this way the slough is separated, and a granulating wound is left, which heals in the usual way, leaving a cicatrix, the character of which varies with the depth of the slough.

Reference has already been made to the fact that Hæmoglobinuria sometimes follows burns, and also that reduction of temperature may occur. These, along with reduction of blood-pressure from dilatation of arteries, probably have to do with the occasional rapid occurrence of death from extensive burns.

If the person survive for some time after the burning, inflammations of internal organs, the lungs, kidneys, serous membranes, are frequently found; also fatty degeneration of the heart and of the liver. These are to be ascribed with great probability to the alteration of the blood.

It is much more difficult to account for the occurrence of the **Duodenal ulcer** after burns. When several weeks elapse before death, there is found, in about 20 per cent. of the cases, one or more ulcers, usually situated in the duodenum near the pylorus, but sometimes in the pyloric region of the stomach. It may be a superficial hæmorrhagic erosion or a deeply penetrating ulcer.

(*b*) **Frost-bite and Chilblain.**—These conditions are produced by the action of excessively low temperatures. We can distinguish three degrees here also.

The common **Chilblain** or **Pernio** is an example of the **First degree.** If portions of the body are frequently exposed to a low temperature and then heated, a chronic or subacute inflammation is induced. This occurs especially in the fingers and toes. There is passive hyperæmia sometimes amounting almost to stasis, so that the part has a livid hue. There is also serous exudation, so that the part is swollen and œdematous; there may be red corpuscles as well as leucocytes in the exudation. Sometimes ulceration occurs.

The **Second degree** includes the **Less severe cases of frost-bite.** The skin has been frozen and too rapidly thawed, the result being such an injury to the tissue as to cause an acute inflammation. The epidermis is raised in blisters, which often contain a bloody serum. There may even be sloughing of the superficial layers of the cutis, and on separation of the slough an indolent ulcer forms.

In the **Third degree**, forming the **More severe cases of frost-bite**, there has been prolonged exposure to very intense cold. The consequence is the complete freezing of part of the body, especially in regions removed from the heart, as the fingers and toes. The tissues are stiffened by freezing, and the blood coagulated, so that sometimes parts can be broken off like glass. When the parts are thawed gangrene sets in. The whole frozen part does not die; there is partial recovery with inflammation. The gangrenous part is separated in the usual way, generally with decomposition (moist gangrene).

(*c*) **Wounds and Excoriations.**—The phenomena connected with the healing of wounds and the formation of granulations have been considered in previous pages. When merely the epidermis is removed by an injury, forming an **Excoriation**, it is restored with remarkable celerity. The epidermic cells at the margin and those of the deeper layers divide and form new cells which restore the surface.

In the case of a deeper wound the epidermis also shows great vigour, and it sometimes advances beyond the line of the other healing processes. The new-formed epidermis may advance over a blood-clot filling up a wound. The epidermis here has a remarkably transparent hyaline appearance and is continuous, not with the Malpighian layer, but with the layers superficial to that. The character of the cells here and their transparency suggest that they may be derived from the stratum lucidum. It may, indeed, be suggested that this layer in the normal skin is composed of young epidermis, and that the loss on the surface is supplied by new-formation here and not in the Malpighian layer.

4. **Septic and Infective inflammations.**—We include here those forms of inflammation of the skin which can be traced to the action of microbes, apart from those which have the characters of the specific new-formations.

(*a*) **Boil and Carbuncle.**—A boil is a localized acute suppurative inflammation with a limited necrosis of the cutis. The irritant finds access by the sebaceous glands or hair follicles, and consists of pyogenic microbes. The source of these may be obscure, but in some cases they are derived from contact with a cadaver. The inflammation manifests itself in hyperæmia and exudation, so that a localized redness and swelling are the results. A piece of skin in the very centre of the inflamed area dies, and a small abscess having formed, the slough is by degrees discharged along with the pus.

The **Carbuncle** is similar in its general characters to the boil, but a much larger piece of skin is involved. The slough is therefore of much greater extent. It sometimes happens that the whole piece of skin in its entire thickness dies and is separated as a dry leathery slough. More frequently the necrosis is less extensive in the superficial layers than in the deeper parts, and the slough is discharged through numerous small apertures.

(*b*) **Lesions from cadaveric poisons.**—In the fluids of the dead body, during the process of decomposition, there are innumerable bacteria of different kinds. Some of these may attack the skin of the dissector or pathologist, and find a lodgment there. The organisms themselves are of very various degrees of virulence. The fluid in the abdomen after septic peritonitis, such as that which occurs in one form of puerperal fever, for example, teems with micrococci, and this fluid is peculiarly virulent when applied to the skin.

Besides degrees of activity in the virus, there are various degrees in the susceptibility of different persons, and of the same person at different times. A state of exhaustion of the body causes a greater degree of susceptibility, and makes the inroads of the virus when once implanted more vigorous than in persons in ordinary health. The inference from this is, that the best treatment for this condition is to leave off work and at once seek rest and fresh air.

The virus very often finds access to the skin without any breach of surface. When a wound is made during dissection it is usually washed thoroughly and sucked, while bleeding is encouraged; in this way the virus may be washed away. But if it gets into the hair follicles or sweat glands it may lodge and multiply undisturbed.

The results are somewhat various. The most severe is the occurrence of an **Acute phlegmonous inflammation**, which rapidly goes on to suppuration. In some cases the inflammation spreads upwards, having the characters of an extending erysipelas. In others the characters are more those of angeioleucitis, the virus extending by the lymphatic vessels, by which it may reach the glands. There may thus occur a suppurating bubo of the axillary glands.

An inflammation of the skin resembling erysipelas may spread from the glands so affected, as the virus, checked in its upward course towards the trunk by the glands, passes outwards to the lymph spaces around. This course of events is shown in the account which Paget has given of his own case in his "Clinical Lectures and Essays." The inflammation may travel along the connective tissue of the skin and subcutaneous tissue, and may even reach the pleura. In the skin its effects may be very severe, resulting in sloughing and profuse suppuration like that in erysipelas. It may even lead to septic infection or pyæmia.

A less severe and more local result is the formation of **Boils** at the seats of inoculation. At first there is usually a superficial pustule, but from this the infection is apt to spread downwards into the deeper layers of the cutis and produce the necrosis and suppuration described above as the phenomena in boils. In other cases the inflammation does not result in necrosis and suppuration, but has a more chronic course, producing what is sometimes called a blind boil, namely, an inflammatory thickening with considerable elevation.

The **Pathological wart** or **Verruca necrogenica** is really a tuberculosis of the skin (see later).

(*c*) **Phlegmonous inflammations. Erysipelas.**—These names are given to acute infective inflammations of the skin. In the case of erysipelas the virus depends on the streptococcus erysipelatis which multiplies more or less abundantly in the lymph spaces and vessels of the skin (see Fig. 716) and subcutaneous tissue. The result is a more or less severe inflammation. At first there is an inflammatory hyperæmia, which advances as the virus extends along the lymph spaces. This, with a moderate exudation of fluid and leucocytes, may be all. But sometimes there is a much more intense inflammation. The skin is infiltrated with leucocytes to such an extent that it is softened and opened out with pus. The epidermis is raised by exudation so that vesicles or pustules are formed. Sometimes the lymph spaces are occupied with fibrine. Besides suppuration, there is often necrosis of portions of the skin so that sloughs are separated with the pus.

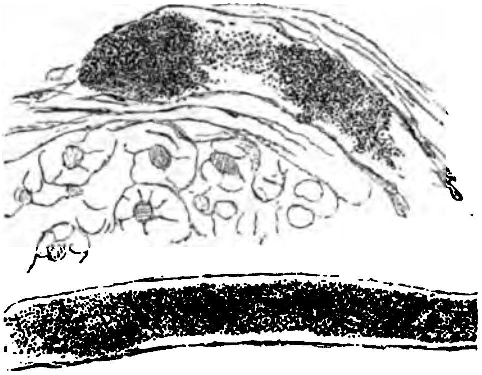

Fig. 716.—From the skin in a case of erysipelas. The upper illustration shows a lymphatic vessel at the border of a sebaceous gland, filled with micrococci. The lower shows a straight vessel similarly filled. × 350.

A somewhat similar phlegmonous inflammation sometimes occurs around septic wounds, such as we have described in cadaveric infection.

(*d*) **Soft chancre, Ulcus molle.**—This, which is the ordinary non-syphilitic venereal chancre, is usually situated on the organs of generation. It is an acute infectious inflammation, which tends to spontaneous recovery. In about 24 hours after infection a vesicle or pustule appears, which rapidly, by loss of the epithelium and molecular necrosis of the cutis, is transformed into an ulcer of small size. It increases in size and sometimes by infection leads to others. The ulcer sometimes shows much excavation, so that the skin is partly undermined. There is frequently an extension to the neighbouring lymphatic glands, the result being a suppurating bubo.

The soft chancre usually heals in about 2 to 4 weeks, and does not give rise to syphilis. On the other hand there may be a simultaneous infection with syphilis, and the hard chancre, which is of slow development, may supervene in 3 or 4 weeks.

Ducrey and Unna have asserted that the infection of the soft chancre is related to a specific microbe which has the form of a bacillus growing in chains (Streptobacillus).

(*e*) **Malignant œdema.**—This depends on the action of a specific microbe, the bacillus of malignant œdema already described (p. 173). The affection usually attacks open wounds, and the most typical result is an advancing gangrene with development of gas, accompanied by acute inflammation.

(*f*) **Splenic fever** or **Anthrax.**—This disease also depends on a special bacillus, which, however, usually extends to the blood, and the patient dies from the general specific fever. There is usually a local affection to begin with, and the disease may remain local. The local affection has the characters of a phlegmonous inflammation of the skin and subcutaneous tissue. Sometimes the appearances of malignant œdema are produced. From these local manifestations the condition is sometimes called **Malignant pustule.**

(*g*) **Hospital gangrene.**—This is an infective disease accompanied by sloughing of the skin. It is due to a specific virus which is supposed to be a micrococcus. The disease occurs in unhealthy hospitals especially in time of war. It attacks open wounds, especially granulating wounds, and is accompanied either by sloughing or molecular necrosis. The gangrene frequently travels along the loose connective tissue and so may undermine the skin, or isolate muscles and blood-vessels.

IV.—SEPTIC NEW-FORMATIONS.

1. **Syphilitic lesions of the skin.**—The various manifestations in the skin are the results of the action of the syphilitic virus. The lesions, like those elsewhere, are either simply inflammatory, or they have the characters of the gumma, forming in the latter case more

or less definite tumours composed of granulation tissue. Even the purely inflammatory lesions have a tendency, when they have persisted long, to present considerable new-formation of granulation tissue. The syphilitic lesions of the skin may be divided into the primary, secondary, and tertiary.

(*a*) The **Hard chancre** has been already described. It is characterized by a hard indurated base due to an infiltration or replacement of the soft and pliant cutis vera by granulation tissue.

(*b*) **Skin eruptions of secondary stage. Syphilides.**—Skin affections are the principal manifestations of this stage, and as the virus is in the blood the manifestations occur as a rule over the skin as a whole, although circumstances may determine a certain local selection. The eruptions are for the most part symmetrical, and they present a peculiar tendency to occur in round patches of a definite size. These patches, by healing in the centres and extending at the periphery, frequently assume a circular or serpiginous outline.

The syphilitic eruptions of the secondary stage are somewhat similar in character to the simple inflammatory eruptions, and they are commonly designated by similar names. There is, however, more tendency in the syphilides to the development of granulation tissue in the skin, and hence the papular forms of eruption are more frequent. Whilst a certain order of frequency is commonly seen, yet there is no absolute fixedness in the rotation of the syphilides. In the earliest periods there is usually a generalized hyperæmia of the skin (*Syphilitic erythema* or *roseola*). A more local development of elevated papules, generally in groups, constituting the *syphilitic lichen*, is the usual form to follow. In these papules, the corium, especially its superficial layers, and to a certain extent the epidermis, are infiltrated with round cells; generally there is desquamation of epidermis, and this is sometimes very prominent. Occurring in the palms of the hands and soles of the feet this desquamation is so characteristic as to give rise to the designation *syphilitic psoriasis*, the resemblance to psoriasis being increased by the fact that the papules after a time coalesce and there is thus produced a generally raised surface.

The **Condyloma** (*Plaque muqueuse*, *mucous tubercle*) is a further and usually a later development of the papule. It occurs generally in situations where two surfaces of the skin are in contact and are thus kept moist, as in the neighbourhood of the genital organs, in the axilla, beneath the mamma, etc. We have here a very marked and extensive infiltration of the papillary layer of the skin with round cells, so that an elevated surface is formed. Sometimes there is a special elongation of the papillæ, so that a warty surface is produced, giving rise to the **Pointed condyloma.** Sometimes the condyloma breaks down on the surface and an ulcer forms.

The syphilitic papules sometimes develop into pustules or vesicles. The pustule forms by the epidermis being raised from the surface, while a fluid inflammatory exudation occurs between it and the corium, which latter remains infiltrated with round cells. The pustule or vesicle and its infiltrated base may enlarge so as to produce a broad bleb on a red raised base (*Syphilitic pemphigus*). The blebs often dry-in and form raised crusts (*Rupia*). In these cases the pustules are as if on the surface of condylomata. This is still more the case in **Pemphigus neonatorum**, which is one of the manifestations of hereditary syphilis. Here the corium is affected somewhat as in the condyloma, but the infiltration has more the characters of granulation tissue. In the condyloma the structure of the skin remains to a great extent, but it is infiltrated with round cells, which are mostly leucocytes. In pemphigus neonatorum, however, the tissue is replaced by a vascular tissue in which are many large cells, the condition approaching to that of the gumma. On the surface of this the epidermis is raised, forming a vesicle or pustule.

(*c*) The **Gumma.**—This is, as we have seen, a special tertiary manifestation. It begins as a hard swelling in the cutis. It increases in size and raises the surface, sometimes forming a tumour of considerable dimensions. The gumma, which may be multiple, is prone to ulceration. The **Gummatous ulcer** somewhat resembles the hard chancre, being an indolent ulcer with a hard base. There may be extensive destruction of the skin by the gradual extension of the ulcer.

2. **Tuberculosis of the skin. Lupus. Scrofuloderma.**—The skin from its position is much exposed to tubercular infection. The cutaneous surface, however, cannot be regarded as very susceptible to this infection. Tuberculosis varies somewhat according to the region of the skin which is affected. The most frequent and characteristic form is Lupus.

Lupus occurs mostly in children, and attacks chiefly the face. The tubercle bacillus having obtained a footing produces an advancing infiltration of the cutis with granulation tissue, in the midst of which giant-cells and sometimes defined tubercles are frequently visible. These, however, are apt to be overwhelmed by the cellular infiltration. There is commonly an exaggeration of the epidermis, so that epidermic processes may penetrate into the granulation tissue. With all this there is a destruction of the specific structures of the skin. The sebaceous glands and hair follicles are destroyed, but it is said that the sweat glands, being situated beneath the cutis, are spared.

The tubercular new-formation undergoes degenerative changes, which lead frequently to ulceration, but sometimes cause cicatrization without ulceration.

The appearances presented to the naked eye vary considerably. There is a local infiltration of the skin, giving an irregular raised surface. The thickening may be very great (*L. hypertrophicus*); or there may be considerable thickening and desquamation of the epidermis (*L. exfoliativus*). Ulceration is frequently manifest (*L. exedens* or *ulcerans*), and the ulcers are often very varied in shape; or ulceration may be absent (*L. non-exedens*).

Lupus is not usually accompanied by tubercular manifestations in other parts, except that the associated lymphatic glands are not infrequently affected.

Scrofuloderma is a term whose definition from lupus is not easily made. It is mostly secondary to tuberculosis in the glands or subcutaneous tissue. The primary seat being usually beneath the cutis the latter is attacked irregularly, and there may be, over an extended surface, many irregular swellings with ulcerations. There may be great thickening of the skin, such as to cause some resemblance to elephantiasis in cases where the leg is affected.

The **Pathological wart**, consisting as it does of a tuberculosis of the skin, has all the characters of lupus. It arises by inoculation of the tubercle bacillus in the course of post-mortem work. There is at first a more or less acute localized inflammation, which gradually subsides into a chronic thickening, the surface of which often shows exaggerated papillæ like those of a wart. There is not much tendency to extension, and not much inclination to healing.

3. **Leprosy** in its cutaneous or so-called tubercular form has been already described.

4. **Elephantiasis** has also been considered at pages 210 and 211.

5. **Granuloma fungoides** (*mycosis fungoides*).—This is a disease of the skin and subcutaneous tissues with close analogies to sarcoma. Any part of the surface may be affected, and the lesions are usually multiple. In the early stages there is erythema with slight swelling; later, nodular elevations, growing often into large fungoid tumours, appear. The tumours are firm, flesh coloured or distinctly red. Necrosis and hæmorrhage may occur. One of the striking features of the disease is the rapid disappearance and reappearance of certain of the tumours.

Microscopically there is nothing very distinctive. The appearances resemble what is met with in lymphadenoma or round-celled sarcoma

(Fig. 717). Although various forms of microbes have been described as occurring in the tissues, the causation of the disease is still unknown.

6. **Frambœsia. Yaws. Pian.**—The disease called by these names, of which the two last are the local designations, presents many analogies with syphilis. Some European observers have believed it to be syphilis, but those who have actually come into contact with the disease have denied the identity. It is met with almost solely in the coloured races, but this is probably because of local circumstances and habits. It is endemic in certain tropical lands, chiefly the tropical parts of America, including the West Indies and parts of North and South America, the West and East Coasts of Africa, many of the African islands, and some of those of the Pacific.

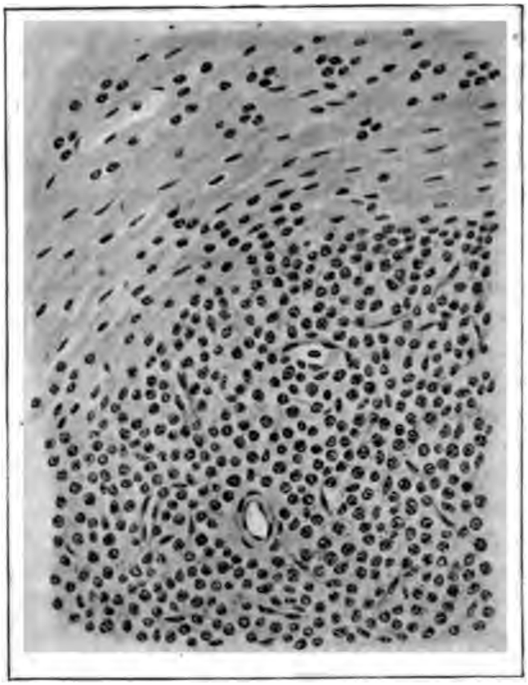

Fig. 717.—Granuloma fungoides. From the margin of a nodule in the subcutaneous tissue. × 150.

The disease is acquired by contagion or inoculation, and begins mostly in childhood, although the first year is usually exempt. A period of incubation of three to ten weeks is followed by the **Primary sore** at first in the form of a papule, followed by an ulcer, the floor of which consists of granulation tissue. The lesion is seldom on the genital organs, and it is not indurated.

There is next a **Secondary stage**, which usually begins after the primary one has healed. It is associated with fever and general symptoms, and is characterized by a cutaneous eruption. The eruption is at first merely congestive, but papules develop, most of which disappear, but some persist and enlarge, and there are formed areas of protruding fungating granulations which are sometimes called tubercles. These tubercles have been compared to raspberries, and from this is derived the name Frambœsia (*framboise* = a raspberry), but they do not usually have the bright red colour of that fruit. There is some discharge of pus from the tubercles. These secondary tubercles may be very few, and they have not a symmetrical arrangement. The microscopic structure is that of ordinary granulations. It is comparable with that of the condylomata of syphilis, but the tubercles are not, like

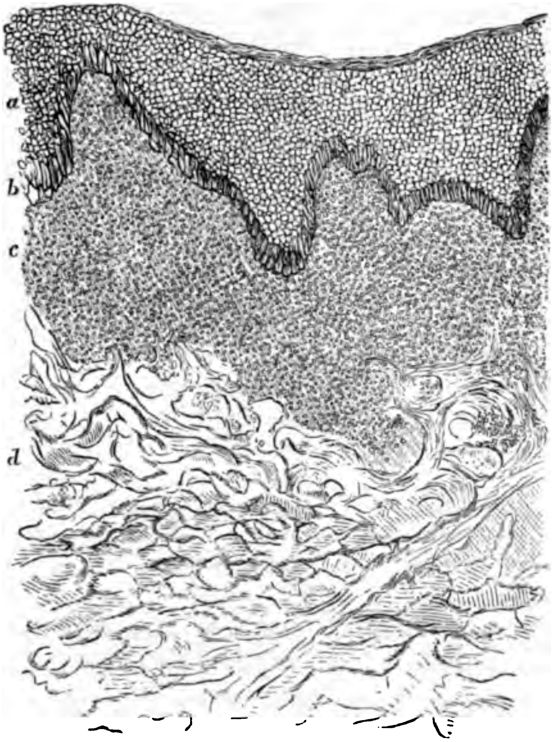

Fig. 718.—Section of skin in frambœsia, from a part where the disease was not very far advanced. The papillary layer of the cutis is seen to be replaced by granulation tissue, while the epidermis is preserved on the surface. × 75.

these, limited to the neighbourhood of the mouth and genitals, and they do not occur in the mucous membranes.

The **Tertiary stage** may, like that of syphilis, supervene long after the healing of the secondary stage, or it may almost directly follow it. There are chiefly extensive ulcerations of the skin, and sometimes of the mucous membranes. There are no proper gummata and there is no caseous condition, but simply an exuberant growth of granulations which break down and form ulcers. At the advancing edge the granulation tissue may be seen advancing in the superficial layers of the cutis, as in Fig. 718. These ulcerations are most common on the legs, and extensive thickenings and ulcerations may supervene so as to produce resemblances to elephantiasis and leprosy. In this stage there is an occasional extension to the periosteum, but not apparently to the nervous system.

The analogies with syphilis are obvious from the above description. The points of difference are chiefly the early age of its occurrence, its endemic character, the fact that the secondary stage is characterized by tubercles of granulation tissue rather than polymorphous eruptions, the difference in structure and locality of the tertiary lesions, and the absence of any affection of the lymphatic glands. From the author's own observation of a case of Frambœsia he is convinced that the two diseases are perfectly distinct.

Literature.—*Frambœsia*—See a very complete account of the dis. with literature, etc., by J. NUMA RAT, Frambœsia (Yaws), with prefatory remarks by JONATHAN HUTCHINSON, 1891; New Sydenham Society Atlas fass., i. and ii., 1902.

V.—TROPHONEUROSES OF THE SKIN.

We include under this heading lesions of the skin in which, by reason of disease of the nervous system, such changes occur in the nutritive processes as to lead to definite anatomical results. The existence of separate trophic nerves for the skin has not been demonstrated. But there are evidences, especially in pathological processes, that trophic centres exist, and that fibres convey impulses of this kind to the skin. The ganglia of the posterior roots of the spinal nerves and the similar Gasserian ganglion seem to contain trophic centres, and the trophic fibres are either identical with the sensory ones or run along with them.

Causation.—We have already seen that certain conditions of the nerves lead to disorders of the circulation in the skin (*vide ante*), and that some of these affections graduate towards inflammations. We have here to consider conditions, more or less definitely related to the nerves, in which pronounced structural changes occur, many of them having the characters of inflammation.

The exact relation of the lesions to the nerves is often difficult to determine. On the one hand, it is undoubted that interference with the nerves by division or by irritation induces lesions of the skin. Again, locomotor ataxia is often accompanied by cutaneous eruptions, especially during the early stage. These are probably the result of the irritation of sensory nerves. Further, there are skin lesions which apparently arise by irritants in the blood attacking the nerves. This possibly applies to some cases of urticaria and erythema nodosum, and is asserted also to have to do with the causation of herpes. On the other hand, it is difficult to assign the exact *modus operandi* of the nerve-condition on the lesions in the skin. The influence may be exercised by means of the blood supply, but also more directly. It can scarcely be thought that the nerve-lesions in themselves are capable of producing inflammations of the skin, for which the action of irritants is necessary, but nerve-conditions may so affect the skin that ordinary stimuli, as of friction, etc., may come to act as irritants and induce inflammation. In such cases the nerve-lesion is the most important element in the causation.

1. **Cutaneous lesions in nerve-leprosy.**—These have been already referred to. They consist chiefly in alterations in colour, with ulcerations which are probably to be ascribed to the anæsthesia.

2. **Cutaneous lesions due to nerve-syphilis.**—When syphilis attacks the peripheral nerves there are cutaneous eruptions, often characterized by long-continued pigmentation. These are distinguished from ordinary syphilides by their persistent local distribution.

3. **Herpes.**—The two principal divisions of herpes are to be distinguished in their general causation, although similar in their anatomical characters. On the one hand, **Herpes facialis** and **Herpes genitalis** occur in the course of a number of acute febrile diseases, such as pneumonia, cerebro-spinal meningitis, and malaria, being particularly frequent in pneumonia. It is probable that the infective agent acts on the nerves of these parts, and so leads to the affection. On the other hand, **Herpes zoster** is related to an unknown irritant which attacks the particular nerve stems, producing neuralgia. The eruption is limited to the distribution of particular nerves, and is strictly unilateral. It is frequently related to an intercostal nerve, or it may occur on one side of the face in connection with a neuralgia of the fifth nerve.

The eruption in the skin is in the form of vesicles which somewhat rapidly pass through a series of changes. There is first a group of slight elevations occupying a reddened patch of skin, and each of these rapidly develops a vesicle; in a few days the vesicle dries up into a crust, under which fresh epidermis is formed. In its details the eruption is inflammatory. There is hyperæmia and œdema of the papillary layer of the skin. The serous exudation collects in the Malpighian layer of the epidermis, separating its cells just as in the case of the small-pox eruption. The vesicle is divided by a network composed of the elongated and contorted epidermic cells, which often present clear spaces or vacuoles in their substance. In the serous contents of the vesicles there are leucocytes, and these may accumulate till the fluid approaches to the nature of pus. The papillary layer is also frequently the seat of infiltration with round cells. Occasionally there is hæmorrhage, and the papillary layer of the skin may be destroyed, so that when healing occurs by granulation a cicatrix may be the result.

The nervous origin of herpes has been abundantly established. Direct injury to a nerve, as by a gunshot or other wound, may cause it. It is to be presumed that, in this case, the inflammatory process in the wound irritates the nerve, and the cutaneous inflammation may be regarded as due to the irritation of trophic fibres.

A herpetic eruption may arise from disease of the spinal cord and brain. In the case of the cord it is chiefly in locomotor ataxia that we meet with herpes, and the eruption is accompanied by the severe pains characteristic of that disease. We know that in locomotor ataxia the posterior columns of the cord are affected, and this would indicate that the cutaneous trophic fibres run in these parts, while the coincidence of neuralgic pains also indicates a sensory locality. It is here again to be presumed that the lesion producing the herpes is an irritative one as indicated by the violent coincident pains. But we may have herpetic eruptions from disease in the brain. There are cases recorded in which one half of the body was affected, and in some of these there was a hemiplegia due to a coarse lesion in the brain. There are also a few cases on record of universal or nearly universal herpes.

4. **Glossy skin.**—This name was applied by Paget to a condition which he observed in connection with injuries or wounds of the nerves. There is here again indication of irritation of the nerves, as there is always neuralgic pain, described by Mitchell as burning pain. The condition also occurs sometimes after an attack of herpes (Paget), and it may be associated with eczema. It may also follow disease of the spinal cord (Mitchell).

The disease occurs mainly in the hand, and especially in the fingers. The affected fingers "are usually tapering, smooth, hairless, almost devoid of wrinkles, glossy, pink, or ruddy, or blotched as if with permanent chilblains" (Paget). The most striking peculiarity is the shining, glossy appearance of the surface as if it had been varnished. The condition has been compared to chilblains, but sometimes the appearance is rather that of highly polished scars, and it more closely resembles morphœa. In the affected parts the hairs mostly disappear, and the nails undergo peculiar changes. The latter become greatly curved, much more than in cases of phthisis, while the skin at the root of the nail becomes retracted, leaving the sensitive matrix partly exposed. The disease affects mainly the fingers and toes, but it may extend to the palm of the hand or the dorsum of the foot. The histological details of this condition are little known.

5. **Scleroderma and Morphœa.**—The name scleroderma adultorum is given to a rare form of skin disease which affects considerable areas and is usually symmetrical. Morphœa or **Addison's keloid** has similar anatomical characters, but occurs in localized patches.

In the more diffuse form of scleroderma proper, extensive tracts of skin are sometimes involved, such as the greater part of the face, the arms, etc. In a case observed by the author, the face, chest, and both forearms and hands were affected, and dry gangrene had occurred in the fingers, which had a stiff black appearance.

The nature of these affections is not quite determined, but many facts point to a nervous origin. There is the symmetrical character of the lesion and its wide distribution, as well as the fact that lesions of the sympathetic have been believed to give rise to it. The lesions, consisting of a slow increase of the connective tissue with atrophy of the special structures, resemble those which occur in muscles as a result of severance from their trophic centres.

In its anatomical details the skin in both forms presents characters which may be summarized as atrophy with chronic inflammation. The papillæ are mostly flattened, and the cutis thinner than normal; the cutis is composed also of more homogeneous connective tissue than usual, having somewhat the characters of cicatricial tissue, and less fibrous than that of the normal skin. This condition extends somewhat to the subcutaneous tissue where the fat is to a considerable extent atrophied, apparently by the encroachment of the connective tissue.

The hairs are also atrophied in the affected areas, and there is alopecia when the patches extend to the hairy scalp. The evidence of chronic inflammation is the existence of abundant nuclei in the altered skin. These are usually aggregated around the blood-vessels, but they are also seen around sebaceous glands and under the rete Malpighii.

Complete recovery seems to be not uncommon in this disease, although it may be slow.

Allied to scleroderma in the general characters of the lesion in the skin is the condition commonly designated **Sclerema neonatorum.** In this disease the skin, usually of the lower extremities, is hard and swollen, so that movement of the limbs is curtailed. When it persists for some time the skin may be like parchment.

Literature.—*Herpes*—Picaud, Des eruptions cutan. consée. aux lésions traumat., 1875; Mitchell, Injuries of nerves, etc., 1872; Barensprung, Charité-Annalen, ix., 1863; Kaposi, Hautkrankh., 1882; Charcot, Dis. of nerv. syst., i. (Syd. Soc.), 1877. *Glossy skin*—Paget, Med. Times and Gazette, i., 1864; Mitchell, loc. cit.; Bowlby, Injuries and Dis. of nerves, 1889. *Scleroderma*—Hilton Fagge, Guy's Hosp. Rep., 1867, xv., 187; Chiari und Mader, Vierteljahrschr. f. Dermat. u. Syph., 1878; Hutchinson, Lect. on clin. surg., 1878; Schwimmer, Die neuropath. Dermatosen, 1883; M'Calman, Glas. Med. Jour., xvi., 1881; Steven, ibid., xxvi., 1886; Erben, Vierteljahrsch. f. Dermat., xv., 1888; Lewin and Heller (literature very full), Charité-Annalen, xix., 1894; Ballantyne (*Sclerema*), Brit. Med. Jour., 1890, i., 403. *Addison's Keloid*—Addison, Published writings (Syd. Soc.), 1869; Hilton Fagge, loc. cit.; Hutchinson, loc. cit.

VI.—HYPERTROPHIES AND TUMOURS OF THE SKIN.

1. **Ichthyosis.**—This is a disease which apparently owes its origin to a congenital defect in the constitution of the skin. The disease itself is sometimes manifest at birth, but if not it begins in the earlier years of life, gradually extends over the whole body, and continues during life. It is in a striking manner inherited (see under Inheritance).

It consists, anatomically, in an affection of the epidermis, which is sometimes greatly thickened and irregular. The thickened epidermis forms scales of large or small size, sometimes producing merely a furfuraceous exfoliation, but in more severe cases giving rise to large plates like fish scales. From this latter appearance the name of the disease is derived. The scales do not consist entirely of epidermis, but contain sebaceous material, which is sometimes so abundant as to give the scales a polished appearance like mother-of-pearl. The large scales may be so fixed as to give an imbricated appearance. The milder forms of the disease, in which there is little more than an excessive scaliness of the surface, are often included under the designation **Ichthyosis simplex** or **Xeroderma**, while the more severe forms, in which there are prominent scales, are distinguished by the name **Ichthyosis cornea** or **Ichthyosis hystrix**.

In the milder forms the cutis is not markedly affected, but in some cases the papillæ are greatly elongated. The substance of the corium is often atrophied, and the subcutaneous fat deficient.

2. **Callosity and Corn.**—This is an exaggeration of the horny epidermis occurring where the parts are exposed to unusual friction. It is a [redacted] a direct provision of nature to protect the [redacted] to which it is exposed. The best

example of the **Callosity** is in the horny hands of workmen, but it is often seen in the feet, at points which are peculiarly exposed to pressure. From the situations of these callosities, as Hebra pointed out, the occupation of the person may often be made out.

The **Corn** (*Clavus*) is closely related to the callosity. Here, also, there is friction, but it is associated with compression. It occurs chiefly in the foot where there is a concentric pressure from ill-fitting boots, and friction against either the boot or a neighbouring toe. There is, as in the former case, an excessive new-formation of horny epidermis, but, by the concentric pressure, the layers of epidermis have their directions changed, and growing against each other, they are projected inwards towards the cutis. There is thus an ingrowing kernel of hard horny epidermis which has given rise to the name of corn. The cutis is irritated and undergoes atrophy. Around the kernel or "core" the epidermis is always thickened, the condition being like that of the callosity.

3. **Common** or **Hard wart** (*Verruca dura*).—This may be variously regarded either as a tumour or a hypertrophy of the skin. The frequently multiple character of the common wart and its grouping suggest an infective origin. It consists of a local exaggeration of the normal structures and occurs in numbers in the same person. A group of papillæ are elongated, and the epidermis over them thickened, so that the characters are those of a hard papilloma.

The **Horn** is of similar structure to the wart, but the papillæ are usually more elongated, while the horny layer of the epidermis is compacted into a more consistent mass which forms a prominent outgrowth (see Figs. 145, 146, pp. 314, 315).

4. **Soft wart** (*Verruca mollis*) and **Pigmented mole** (*Nævus pigmentosus*) are closely allied conditions. They are very often congenital, or they occur very early in life, and usually remain stationary throughout life. They are small or large elevations of the skin, either colourless or pigmented, and frequently beset with hairs. Many of them present the structure shown in Fig. 719, which places them in the category of true tumours. They are covered by epidermis which shows little difference from the normal. But instead of the normal tissue of the cutis beneath the epidermis there are masses of cells separated by connective tissue. The cells in these nests are usually large and resemble large sarcomatous cells. The presumption is that these structures are really survivals of the fœtal condition, and their importance in relation to tumours has already been referred to. In their structure it will be observed that these warts are much more like tumours than the ordinary warts, and that their tissue conforms to

that of the **sarcomas.** Sometimes a soft wart is composed of a mass of adipose tissue covered by epidermis.

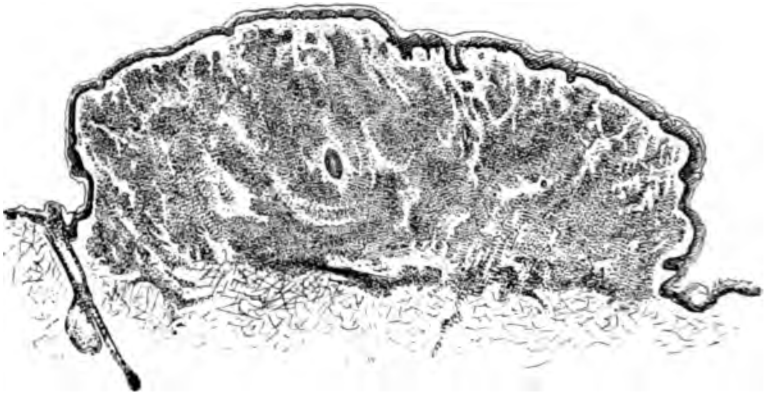

Fig. 719.—Section of a soft wart. It is covered with epidermis and consists of a very cellular tissue. The cells are spindle-shaped. To the left a hair-follicle and a sebaceous gland are shown.

5. **Angioma. Vascular nævus.**—In the skin we meet with all the three forms of vascular tumour already referred to—the venous, capillary, and cavernous. The ordinary nævus, which is in the form of a flat, more or less extensive area of a bright or bluish-red colour, consists essentially of enlarged veins. This seldom becomes prominent

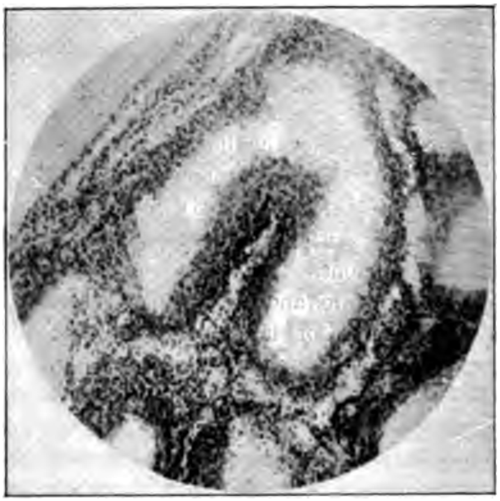

Fig. 720.—Angio-sarcoma of arm. There had been a cavernous angioma first noticed at ten years of age, but increasing gradually from the age of twenty-one. It had grown more rapidly for the last four or five years. Before removal it formed a prominent erectile tumour. The patient was a man aged forty-five years. × 100.

and is not erectile. It is a congenital lesion, and its origin has been ascribed to faulty union of the fœtal fissures, more especially the branchial clefts. According to Unna, however, it is due rather to pressure of the fœtus against the more resisting maternal parts, especially in cases when the amnionic fluid is deficient. The capillary and cavernous angiomata are more prominent tumours. Whilst mostly, like the venous form, congenital in origin, these are liable to enlarge during extra-uterine life. In some cases the cavernous form, after many years of quiet existence, takes on a sarcomatous action, so as to form an angiosarcoma, as shown in Fig. 720, in this respect showing analogies with the congenital soft wart. When this occurs the walls of the vascular spaces become highly cellular as shown in the figure. These cellular trabeculæ, it will be observed, have their own capillary vessels.

The most frequent seat of vascular nævi is the head, more particularly the eyelids, cheeks, ear, nose, and lips. According to Unna, they are present, often merely as slight marks, near the vertex of the head in from 10 to 20 per cent. of persons. They occur less frequently on the trunk and limbs.

6. **True keloid.**—This is an elevation of the skin which has in its marginal parts branching processes extending out. There is evidently considerable contraction and dragging produced by the central tumour and the radiating processes, so that the skin is puckered around as in the case of a contracting cicatrix. The lesion has many of the characters of a definite tumour. It is composed, in the fully developed state, of dense connective tissue which may be unduly cellular. The new-formation has its seat in the deeper layers of the cutis, and it is stated that the papillary layer is intact. In the earlier stages it consists mainly of spindle cells, and Virchow therefore regarded it as a sarcoma. The analogy to the sarcoma is supported by the fact that the tumour recurs on removal. The most common site of keloid is the front or back of the chest, but it is found in other parts.

The name of **False keloid** is sometimes used to designate a condition which occurs in **Scars**. A localized thickening, usually in the midst of a large cicatrix, as from a burn or an ulcer, presents itself, and there are raised processes passing out from it as in the true keloid. This is commonest in tubercular subjects.

7. **Molluscum contagiosum** (*Epithelioma molluscum*).—This name is applied to small multiple growths of the skin, occurring chiefly on the face and showing a preference for the eyelids, but sometimes extending so as to be almost universal over the body. The individual nodules have been compared to pearl buttons, which they resemble in

their circular shape and central depression, but they are usually pink in colour. There is considerable elevation of the little growth, and, although generally sessile, it sometimes becomes pedunculated and may even drop off.

The little nodule (see Fig. 721) consists essentially of new-formed epithelium, in the cells of which the peculiar bodies form which some regard as parasitic protozoa (see under Cancer). The whole tumour looks like an enlarged and altered sebaceous gland with its lobules and central duct, but the observations of Virchow, Thin, and others render it very doubtful if the lesions have this origin. Thin believes that the infective agent gets in by the hair follicles and stimulates the Malpighian layer of the epidermis to new-formation. The sebaceous glands are really pushed aside by the growing tumour.

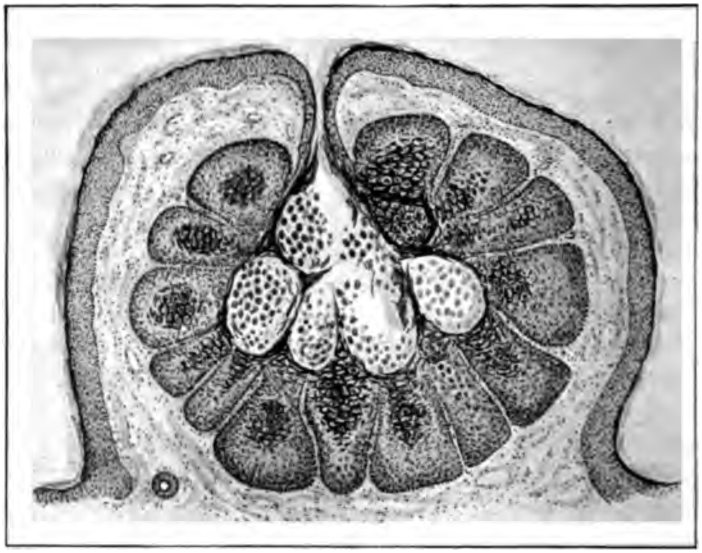

Fig. 721. Molluscum Contagiosum. × 200.

The disease depends on some virus, and, as the name implies, it is contagious. It generally occurs in groups in the same person, as if spreading, and several members of the same family, or several persons living together, are usually affected simultaneously. It is usually seen in children, but occurs also in adults.

8. **Fibroma molluscum.**—This condition is to be carefully distinguished from that just mentioned. In it there are large numbers

of tumours over the surface of the body, which are composed of fibrous tissue. The annexed figure (Fig. 722) gives a graphic picture of the condition. The subject was a Hindoo aged 85 years, who had been affected for 44 years. His general health did not suffer.

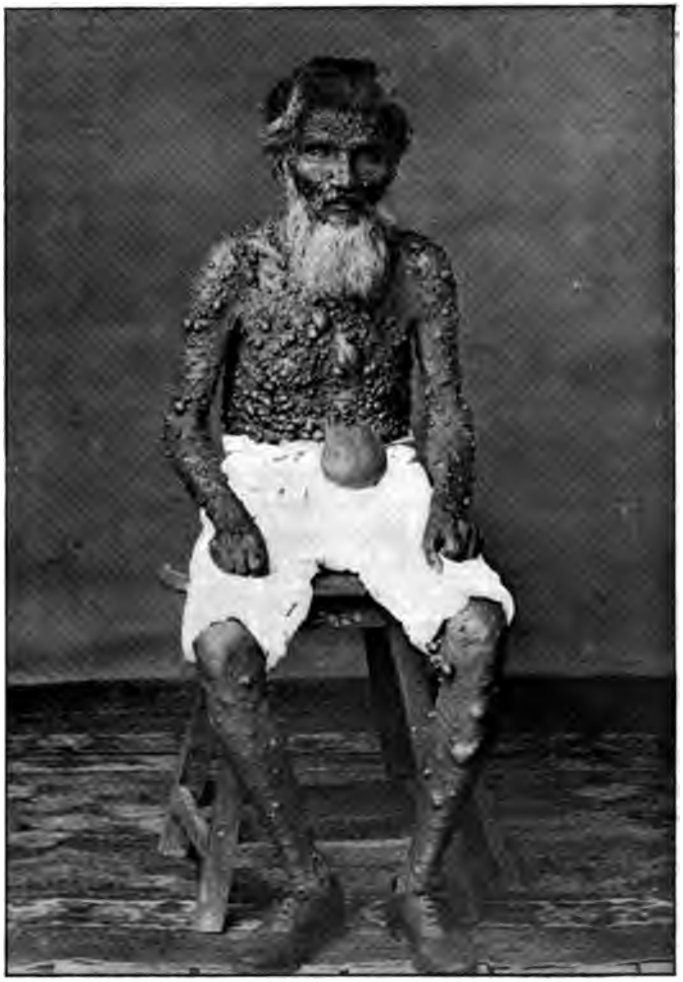

Fig. 722.—Fibroma molluscum in a man aged eighty-five years, who had been affected for forty-four years. (From a photograph lent by Dr. H. E. Jones.)

Small **Fibromas** have been frequently observed in the skin in rheumatic cases, especially in children. They are usually temporary. Larger tumours have been observed associated with rheumatism in adults.

The **Myoma** of the skin occurs either as a single small tumour, constituting the **painful subcutaneous tubercle** of Wood (see under Myoma), or in the multiple form.

9. **Xanthoma** or **Xanthelasma.**—This name is applied to slight elevations of the skin of a yellowish colour. They occur mostly on the eyelids, where they appear as firm yellow patches, which are usually quite flat, but may be slightly tuberculated. They consist of firm connective tissue in which finely divided fat granules are abundantly present. The latter give the opaque yellow character to the lesion.

10. Of the remaining simple-tissue tumours, the **Lipoma** is common, originating in the subcutaneous tissue. The **Myxoma** is not infrequent, and the **Enchondroma** and **Osteoma** very unusual.

11. **Xeroderma pigmentosum.**—This disease, with its prolonged course and its final tendency to cancerous development, forms one of the most curious and most difficult problems of pathology. It seems to have as a predisposing cause a peculiar sensitiveness of the skin to sunlight. This is shown by the fact that it occurs in the parts of the skin exposed to the light, and that it usually commences in the second year of life, this being the time when children begin to run about and become more exposed to the sunlight. That this is a constitutional peculiarity appears from the frequency with which the disease occurs in several members of the same family.

The disease begins usually in spots of hyperæmia on the exposed parts of the body, which assume the form of pigmented areas resembling ordinary freckles. There follow on this, usually in the course of years, various alterations in the skin in the form of slight warty projections, atrophic areas in which the skin is hard and tense, and local dilatations of the vessels. This goes on usually for years and is succeeded by a condition in which in one or more places the warty projections assume cancerous characters, the epidermic cells penetrating downwards into the cutis vera, in the manner of a regular **epithelioma.** The cancer ulcerates, and as it extends at the same time, there may be very great destruction of the parts, even down to the bones. In a case seen after death by the author, there occurred destruction of almost the entire side of the face, along with large portions of the temporal bone and the superior and inferior maxillæ.

A somewhat analogous disease occurring in adults has been described by Unna under the name of **Seaman's skin.** Exposure to the weather sometimes induces in seamen a condition of cyanotic redness followed by pigmentation, thickening of the horny epidermis, etc., and on this, at long intervals, **Ulcerating cancer** develops, just as in the other case.

12. **Sarcoma.**—This form of tumour is of somewhat frequent occurrence, and we may have round-celled, spindle-celled, or melanotic growths, which may sometimes assume considerable dimensions. Sarcomas sometimes originate in soft warts or moles, and when they do so they frequently present a similar structure to that described above, namely, masses of large round cells in a stroma. To this form the name **Alveolar sarcoma** is applicable. Sarcomas originating from moles are peculiarly apt to be pigmented.

Sarcomas rarely occur as secondary tumours in the skin, but a case was known to the author where multiple tumours composed of round-celled tissue formed at intervals, in the subcutaneous tissue, and some of them disappeared. These were either round-celled sarcomas or malignant lymphomas.

13. **Cancers.**—The **Epithelioma** of the skin forms the majority of the flat-called epitheliomas, and it has been already considered.

The two most interesting forms are the ordinary flat-celled epithelioma and the rodent ulcer. The former is met with most frequently in the lower lip, but also occurs not uncommonly in the penis and scrotum. In the last mentioned seat it appears to occur with special frequency in chimney-sweepers and in workers in paraffin-refineries. The rodent ulcer occurs in the face, especially on the eyelids and the side of nose. It occasionally is met with on the trunk and extremities.

The flat-celled epithelioma not infrequently occurs in scars or in old ulcers (see Figs. 184, p. 348, and 186, p. 350). In the latter case it may penetrate into the sinuses, and even reach cavities in bones.

Ordinary cancer is of rare occurrence in the skin, but cases have been observed to which the names scirrhus and soft cancer have been given. It may develop in a lupus. **Pigmented cancers** are of occasional occurrence, and they are of importance on account of their tendency to form secondary tumours, first in the lymphatic glands and then throughout the body. They are, however, much less frequent than melanotic sarcomas, with which they are apt to be confused.

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VII.—PARASITIC DISEASES OF THE SKIN.

We have already seen that certain forms of inflammation are associated with the presence of microbes, especially the infective inflammations. We also saw that leprosy depends on a specific bacillus. These do not require further treatment here.

Fungi are present in three principal forms in the skin.

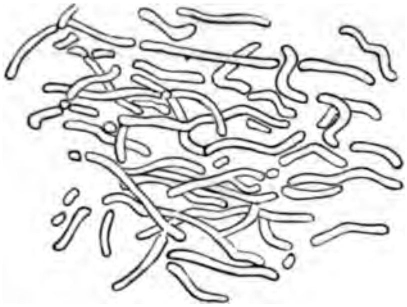

Fig. 723.—The fungus in favus. Short threads are shown. × 350.

1. **Tinea favosa** or **Favus.**—This is a disease chiefly of the hairy scalp, although it occurs on other parts of the skin and also in the nails. On the scalp it forms crusts about the size of split peas, which, when removed, are usually seen to be somewhat cup-shaped, the convexity of the cup being next the skin, the latter presenting a corresponding depression. If the cups, which have a characteristic saffron yellow colour, be divided with a knife they are seen to have a porous appearance, the interstices being filled with air, and they are brittle, so that they can easily be broken down in water.

The crusts are formed of fungus along with epidermic scales and their debris. The fungus is the **Achorion Schoenleinii,** which occurs for the most part in the form of short tubes (Fig. 723) with rows of conidia spores. The proper mycelium is not jointed, but the receptacula are. The fungus appears to begin its growth in the hair follicles, enveloping the hair and passing into it. It also passes into the hair sheath and epidermis around, separating the cells and destroying them. It has its seat thus in the first instance beneath the horny layer which may be continuous over it. It does not invade the true skin, but the crust may cause inflammation around which may go on to suppuration and ulceration. As a rule, however, it only affects the epidermic structures, the hairs being largely destroyed where the crusts are developed.

When it attacks the nail, it forms a yellow crust, the tissue of the nail being opened out and softened by the fungus penetrating between the horny cells.

2. **Tinea tonsurans** or **Ringworm.**—This is also a disease chiefly of the scalp, but the same fungus attacks the beard and the parts of the body devoid of hair. The disease is therefore divisible into three forms, **Tinea tonsurans proper, Tinea sycosis,** and **Tinea marginata.**

The fungus, called the **Trichophyton tonsurans,** is chiefly in the form of spores which infiltrate the hair and its sheath, as well as, to a less extent, the epidermis around. The mycelium is only represented by short threads. The hair shaft is greatly penetrated by the spores, which break it up.

According to M. Sabouraud, there are two principal forms of the trichophyton, one with small spores (trichophyton microsporon) and one with large spores (trichophyton melagosporon). The former is chiefly that of children and its special seat of growth is the substance of the hair, while the latter is chiefly that of the beard and smooth parts of the skin. The fungi are readily cultivated.

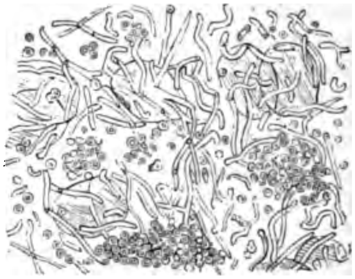

Fig. 724.—Fungus in pityriasis versicolor. Threads are seen with groups of spores. × 500. (Duhring.)

3. **Pityriasis versicolor.**—In this disease there are patches of a yellowish or dark brown colour with a scaly surface, and occurring chiefly on the trunk in adults. If the surface be scraped and the scaly products examined under the microscope (best with the addition of liquor potassæ, both in this case and the others); there will be found epidermic cells with the elements of a fungus, the **Microsporon furfur.** There are usually abundant mycelium threads, and the spores are in rounded masses, which have been compared to bunches of grapes (see Fig. 724).

Of the lesions due to **Animal parasites** the most important is scabies.

Scabies.—This disease is characterized by the formation of papules, vesicles, pustules, and other signs of inflammation due to the effects of the **Acarus scabiei** or **Sarcoptes hominis** (see under Animal Parasites). The female of this insect penetrates into the substance of the peidermis, forming tunnels and depositing ova as it proceeds.

The inflammatory conditions are the result partly of the irritation of the acarusand its embryoes, and partly the effect of the scratching induced by the itching. The primary lesion is a papule running into which a minute furrow is visible to the naked eye. The papule is produced by the opening up of the epidermis and swelling of the papillary layer, which is infiltrated with serous fluid and round cells.

Vesicles and pustules are produced when the inflammation is more severe, and are met with chiefly in children and persons with delicate skins.

The **Acarus folliculorum** is a parasite frequently met with in the sebaceous follicles.

The Parasitic insects are referred to under Animal Parasites.

The **Larvæ of insects** are occasionally met with in the skin. The ova are deposited in the skin, and the larvæ, having developed, may traverse the skin and subcutaneous tissue for a considerable distance till they present at some part and are squeezed out or extracted. They may produce considerable inflammations in the form of boils or swellings.

SECTION XII.

DISEASES OF THE EYE AND EAR.

A.—**The Eye.** I. **The Conjunctiva**, chiefly Inflammations, catarrhal, purulent, and infective (granular conjunctivitis). II. **The Cornea.** 1. Retrograde changes (arcus senilis, conical cornea); 2. Inflammations, sometimes with vascularization of cornea, Pannus; may lead to Ulcers and Staphyloma. III. **The Sclerotic.** IV. **The Iris.** Various forms of Inflammation, serous, fibrinous, purulent. Syphilis and Tuberculosis. V. **The Ciliary body and choroid.** Inflammations. VI. **Glaucoma.** VII. **The Lens.** Forms of cataract. VIII. **The Optic nerve and Retina.** 1. Optic neuritis and choked disc; atrophy of optic nerve. 2. Retinitis, albuminuric and pigmentary; 3. Embolism of retinal artery; 4. Detachment of retina. IX. **Affections of eye as a whole.** 1. Sympathetic ophthalmitis; 2. Errors of accommodation; 3. Tumours, chiefly sarcoma and glioma; 4. Parasites.

B.—**The Ear.** I. **External Ear.** 1. The auricle, chiefly hæmatoma; 2. External auditory canal; inflammations and foreign bodies; 3. Tympanic membrane. II. **Middle Ear.** Structure. 1. Inflammations; chronic, leading to adhesions and sclerosis; acute suppurative, causing perforation of the membrane; and chronic suppurative, leading to polypi, caries and necrosis, suppurations in brain, membranes, etc.; 2. Syphilis and tuberculosis; 3. Sebaceous tumours. III. **Internal Ear**, subject to inflammations, etc., chiefly by extension from middle ear or brain. Ménière's disease and deaf-mutism.

A.—THE EYE.

THE eye, with its appendages, composed of a number of separate tissues delicately adjusted to the requirements of vision, is liable to the usual pathological changes. From the facility with which it is observed, slight differences in the appearances produced are readily appreciated, and hence a considerable degree of complication exists in the nomenclature of affections of the eye.

I. Affections of the conjunctiva.—The conjunctiva is liable to the various lesions of mucous membranes, the chief being inflammation.

1. Conjunctivitis.—The irritant exciting inflammation of the conjunctiva may be a very simple one, such as dust or cold, and in such cases the inflammation is usually slight and evanescent, being characterised by little more than **Hyperæmia**, with more or less serous exudation. In most cases of severe conjunctivitis, the irritant is a morbid poison, and the disease is contracted by contagion.

(*a*) In ordinary **Catarrhal conjunctivitis**, the exact nature of the irritant is not determined, but most if not all cases are contagious. The disease is characterized by hyperæmia eventuating in a mucous or muco-purulent exudation.

(*b*) **Purulent conjunctivitis** (*Purulent ophthalmia*) is due to a pyogenic microbe. This is, in a large proportion of cases, the gonococcus, so that the term **Gonorrhœal ophthalmia** is nearly equivalent to purulent conjunctivitis in the adult. A purulent conjunctivitis occurring in new-born children, and hence called **Ophthalmia neonatorum**, is generally due to infection from the maternal parts during parturition. In this form microbes have been observed, in most cases the gonococcus, but there is still some doubt whether this is so in all cases.

The pyogenic virus in purulent conjunctivitis induces a violent inflammation rapidly passing on to suppuration, and, if neglected, sometimes leading to necrosis and ulceration of the cornea.

(*c*) **Granular conjunctivitis** or **Trachoma** is a more chronic inflammation of the conjunctiva which is also due to a specific virus, which Sattler asserts to be a micrococcus, but this is not absolutely determined. The disease is contagious, occurring sometimes in schools and in armies. Egyptian ophthalmia was a form observed in the French army in Egypt, and introduced by it into France and thence into this country. While due to a special virus, the disease occurs chiefly in unhealthy persons, and is hence most prevalent amongst the poor.

The lesion is in some respects like that in the specific new-formations, such as tubercle or frambœsia. There is a localized formation of round-celled tissue in a delicate reticulated meshwork, so that it resembles lymphatic-gland tissue. These new-formations are usually defined and appear as if surrounded by a distinct capsule, in this respect also resembling lymphoid follicles. There seems little tendency towards further development of this tissue, but the follicles frequently burst and discharge on the surface. These lesions are accompanied by catarrh, and by their mere presence, especially when on the conjunctiva of the upper lids, they often produce considerable irritation of the cornea which also becomes infected by the disease. In the more chronic forms the conjunctiva may be indurated by cicatricial new-formation, and this is accompanied by atrophy of the lymphoid masses. A somewhat frequent result of granular conjunctivitis is the vascularization of the cornea, to which the name **Pannus** is applied. **Localized amyloid degeneration** sometimes occurs in the new-formed follicles in trachoma, this fact also tending to associate the affection with the specific new-formations. The amyloid condition is found in the cells and fibres, but not in the vessels (Leber).

(*d*) **Diphtheritic conjunctivitis** is a rare condition occurring along with diphtheria in the throat. There is necrosis, ulceration, and violent inflammation.

2. **Tuberculosis** is of rare occurrence in the conjunctiva, but tuberculous persons seem liable to a subacute conjunctivitis which is often called scrofulous.

II. **Affections of the cornea.**—The corneal epithelium is usually affected in the various inflammations of the conjunctiva, being exposed to the same irritations. Its peculiar structure, and especially the absence of vessels, render it somewhat liable to necrosis and ulceration.

1. **Retrograde changes in the cornea.**—A very common lesion is **Arcus senilis**, which in some people comes on in middle age. It consists of a fatty degeneration of the cells and fibres of the cornea along a defined line near the periphery of the cornea, but separated from it by a line of unaffected tissue.

The term **Conical cornea** or **Keratoconus** is applied to a condition in which, on account of weakness in the central parts of the cornea, the pressure from within the bulb of the eye forces out this part and so renders the cornea conical. The central part being furthest removed from the source of nutrition most readily suffers when the general condition of the body is reduced, and so yields.

2. **Inflammations of the cornea.**—The cornea, although non-vascular, is subject to inflammations even of an acute suppurative character. The inflammatory exudation passes into the canals and spaces with which the cornea abounds, and by its presence produces a clouded or opaque condition.

The cornea takes part in the acute inflammations of the conjunctiva, being liable to suppuration, softening and sloughing. In addition, chronic inflammations begin external to, or arise in the cornea itself, some of them being due to direct irritation, and some to the presence of ulcers.

Vascularization of the cornea is a frequent result of chronic inflammation. It frequently occurs in the upper part in cases of **granular conjunctivitis**, in which case it is ascribed to the irritation of the rough conjuctiva rubbing against the cornea. The superficial layers of the cornea become the seat of new-formation of blood-vessels, which frequently cover the whole surface. This condition is called **Pannus**, and it is generally recovered from when the primary affection is removed.

A more profound vascularization occurs in some cases in the form of localized crescentic areas at the upper and lower borders of the cornea. This form has been ascribed to nervous lesions. Vascularization also not infrequently attends ulcer of the cornea, a fasciculus of vessels running in from the border to the ulcer.

Interstitial keratitis is a name given to cases in which the cornea assumes an opaque appearance. It is met with chiefly, as Hutchinson pointed out, amongst persons who are the subjects of **Hereditary syphilis**, in whom it is associated with a special condition of the teeth (see under Syphilis). The cornea has in the milder cases an appearance compared to that of ground glass. The actual histological condition of the tissue is various. There may be simply an infiltration of inflammatory products, or there may be more profound changes in the tissues, sometimes even a kind of cicatricial condition.

Herpes sometimes attacks the cornea along with the skin in the course of one of the branches of the fifth nerve (*Zona ophthalmica*). The eruption may lead to an ulcer or even perforation of the cornea.

Paralysis of the fifth nerve also leads to inflammation and ulceration of the cornea (*Neuropathic ophthalmia*). The cornea becomes cloudy and opaque, and ulcers form which may perforate. These results have been variously ascribed, on the one hand to the anæsthesia, which admits of injuries to the eye and exposes it to the presence of foreign bodies without their being felt, and, on the other, to a special affection of the trophic nerves.

Another form of Keratitis is that which occurs when, in consequence of great weakness in the patient, the eyelids are not closed, and the lower part of the cornea undergoes desiccation (*Keratitis e lagophthalmia*). There may be ulceration in consequence.

Ulcers of the cornea arise, as indicated in the remarks made above, under a large number of different circumstances. Ulcers heal by the new-formation of connective tissue, which fills the gap. As this has not the structure of the corneal tissue it is more or less opaque, and appears in the clear cornea as a white area. These areas, being weak, are liable, if large and central, to yield before the pressure within and form a bulging outwards, a condition named **Staphyloma** of the cornea. The iris is frequently adherent to the cicatrix and is often protruded in a staphyloma.

III. **Affections of the sclerotic.**—The sclerotic is a dense connective tissue membrane, which, on account of the paucity of vessels and nerves, and from its well-protected position, is little liable to primary disease. Inflammation extends from the conjunctiva without, but more frequently from the choroid within, and may cause softening so as to produce a staphyloma of the sclerotic.

IV. **Affections of the iris.**—The iris is a very vascular body which lies in a closed cavity occupied by the aqueous humour. The cavity is lined by a serous membrane, and the diseases are like those of serous cavities.

Inflammation occurs in the iris as a result of traumatic, rheumatic, or still more frequently of syphilitic irritation. The inflammation is usually acute, but its severity varies. Different forms have been described according as the exudation is serous, fibrinous, or purulent. Descemet's membrane, which covers the posterior surface of the cornea, takes part in the inflammation. **Serous iritis** is the mildest form, and leads to distension of the anterior chamber by the accumulated fluid. This fluid contains leucocytes, which occasionally render it somewhat turbid. **Fibrinous iritis** (also called *Plastic iritis*) is more severe and is accompanied by a fibrinous exudation, which appears most commonly at the edge of the pupil, but also presents itself on the posterior surface, and sometimes on the anterior. The exudation fixes the iris by forming a membrane in the pupil, or more commonly by glueing it to the lens. This adhesion to the lens (called *Synechia*) is a serious part of the lesion, as it is apt to become permanent. As the inflammation progresses the fibrinous exudation becomes replaced by the formative cells of granulation tissue, and new-formed blood-vessels pass into it. The regular development into spindle-celled tissue and connective tissue occurs, and, just as in the case of the pleura, permanent adhesions are the consequence. Sometimes the new-formed membrane fills the pupil and obscures the vision. The iris itself is the seat of new-formation of connective tissue, which may cause considerable atrophy of its proper tissue. On the other hand, hypertrophy of the iris sometimes results. **Purulent iritis** is more severe. It causes an opening out and softening of the tissue of the iris, while the anterior chamber is filled with pus.

Inflammations of the iris are liable to extend to the ciliary body and choroid (*Irido-choroiditis*).

Syphilis has already been mentioned as a cause of iritis. It is so in the secondary stage, producing an acute inflammation usually of the fibrinous kind. A formation of gummata is an exceedingly rare occurrence.

Tuberculosis of the iris is also rare, but the condition called Granuloma is really a tuberculosis. There is inflammation with development of tubercles and destruction of the eyeball.

V. **Affections of the ciliary body and choroid. Cyclitis. Choroiditis.**—The ciliary body is highly vascular, and is engaged in the secretion of the humours of the eye. Being very active it is peculiarly liable to acute inflammations, more especially as it is related anatomically both to the iris and choroid, and is apt to partake in the inflammations of both.

The choroid is also a vascular structure, containing a layer of pigment cells on its inner or retinal surface. Inflammation of it is not usually acute, except in sympathetic ophthalmia (see further on), and, when chronic, it causes disturbances of the pigment, which produce alterations in the ophthalmoscopic appearances. Sometimes a formation of true bone occurs in the choroid in chronic inflammation, and such an ossification seems a usual occurrence when the eye has undergone atrophy from injury (Fig. 725).

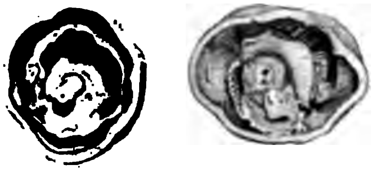

Fig. 725.—Ossification of choroid, etc., in an atrophied eye.

VI. Glaucoma.—This is an important disease in which the ciliary body and iris seem specially concerned. It consists in an increase of the pressure of the fluids inside the eyeball, with consequent injury to the structures of the eye.

The **secretion** and **absorption** of the intraocular fluids have been made the subject of much study and experiment. As the withdrawal of the aqueous humour is quickly followed by its replacement, there seems no doubt that an active secretion goes on in the eye. It is generally agreed that the ciliary body is the chief agent in supplying both the vitreous and aqueous humours, the latter passing through the pupil to the anterior chamber. The principal absorption of fluid is probably at the periphery of the anterior chamber, at the angle formed by the iris behind and the cornea and anterior part of the sclerotic in front. This space is called variously the sinus of the anterior chamber and the filtration angle. This sinus is in communication by means of spaces in the ligamentum pectinatum with Schlemm's canal, which is a channel running round the eye near the boundary between the sclerotic and the cornea. This canal again communicates with the veins of the anterior part of the sclerotic. The retention of this filtration angle or sinus is thus necessary to the absorption of the aqueous humour. Increase of the intraocular pressure may be produced by excessive secretion of fluid, or by defective absorption, but it is mainly by the latter that it is brought about.

Glaucoma results chiefly from interference with the sinus mentioned above. Such interference takes place when, by reason of enlargement of the ciliary body, the base of the iris is pushed forward and so fills up this angle. In most cases the iris is pushed forward so as to be in contact with the cornea, and in many it is actually adherent so as to abolish the sinus. The cause of this displacement has been variously stated, and is not well understood. According to Priestley Smith there is usually, as a predisposing cause, smallness of the globe, and a consequent forward displacement of the lens carrying the iris with it. The sinus being already curtailed, an inflammation or merely a congestion of the ciliary body may push forward the iris so as to close the angle. Besides these cases of more obscure origin, which are included under the designation of Primary glaucoma, the intraocular pressure is increased in some other diseases, of which the chief are tumours. These may act directly by increasing the contents of the globe, but they are also found to produce the glaucoma by pressure on the sinus.

The effects of the increased pressure are seen chiefly in the retina and optic nerve. The optic nerve entrance is less resistant than the sclerotic, being formed by the lamina cribrosa, which gives passage to the fibres of the nerve. This structure yields, and is hollowed out so that a depression is produced in the fundus of the eye. Atrophy of the nerve fibres is a necessary consequence with advancing blindness. The cornea is also rendered dull and obscure and non-sensitive.

VII. **Affections of the lens.**—The only affection of the lens requiring special notice is **Cataract**. This consists in an opacity of the lens or its capsule, such as to interfere with vision. It sometimes occurs as a congenital affection, the lens being imperfectly formed. It is most frequently a senile change, but it also occurs as a result of injury and is an occasional consequence of diabetes.

At birth the lens is soft throughout, but as years go on the centre becomes dense, so as to form a hard nucleus while the periphery remains soft. The hard nucleus is not liable to change, but the soft cortex may undergo alterations. These consist in a formation of fat amongst the fibres which constitute the lens, and the loosening and separation of these fibres. The process goes on till sometimes the affected part of the lens consists of a detritus in which are fat, cholestearine, and remains of fibres. The dense nucleus may sink down in this softened substance. In senile cataract there is always the dense nucleus, which may be of considerable bulk.

In **Capsular cataract** the epithelial cells, which line the capsule, undergo changes, which may be spontaneous or the result of inflammation. They multiply and cause opacity by their abundance and by retrograde changes to which they are liable.

VIII. **Affections of the optic nerve and retina.**—These parts form really a prolongation outwards of the cerebrum, and are surrounded by processes from the membranes of the brain. The dura mater forms a sheath around the nerve as it passes to the eyeball. This sheath is composed of dense connective tissue, and is continuous with the sclerotic, which is composed of similar tissue. Within this sheath the arachnoid is continued as a loose covering as far as the eyeball, where also it becomes continuous with the sclerotic. The pia mater closely invests the nerve and sends processes amongst its fibres. Between the external sheath or dura mater and the optic nerve there are lymphatic spaces continuous with those of the soft membranes. The nerve itself is composed of medullated nerve fibres running in bundles and enclosed in connective tissue. On reaching the eyeball the nerve bundles pierce the sclerotic, which here forms a perforated membrane (*Lamina cribrosa*). At the same time they lose their medullary sheath and are distributed as non-medullated fibres inside the globe. From the optic nerve entrance, which forms a round disc, the fibres radiate outwards around the eyeball where they are in contact with the vitreous. They are very transparent, as the rays of light require to penetrate them in order to reach the rods and cones which are on their outer surface. The nerve fibres, with the rods and cones and the granular layers, constitute the retina.

1. **Œdema and Inflammation of the optic nerve** (*Optic neuritis, Choked disc*).—A series of lesions is included here, the pathology of which is still far from being understood. Affections of the optic nerve are frequent in consequence of tumours of the brain, and these have partly the characters of a simple œdema and partly those of inflammation. Tumours of the brain produce these changes whatever may be their seat. Inflammations of the membranes affect the optic nerve less frequently. There are also inflammations of the nerve of obscure origin.

Tumours of the brain, and other lesions which lead to increased intracranial pressure, produce œdema of the sheath of the nerve with interstitial inflammation. The œdema of the sheath is accompanied by swelling of the intraocular termination of the nerve from venous hyperæmia and œdema. It is this œdema and engorgement which is called Choked disc. It is difficult to explain why tumours of the brain should produce this effect, but it seems likely that by increasing the intracranial pressure they obstruct the passage of the lymphatic fluid in the spaces around the nerve. The retained fluid is perhaps specially irritating, and induces a chronic interstitial inflammation.

Whether originating in tumour of the brain or not, an interstitial inflammation of the optic nerve leads to sclerosis with atrophy of the proper nervous elements.

Atrophy of the optic nerve arises in the manner just mentioned. It may arise also in locomotor ataxia, by a similar process to that occurring in the cord in that disease, namely, a sclerosis characterized by increase of the connective tissue and atrophy of the nerve fibres. These changes are seen by the aid of the ophthalmoscope chiefly as an abnormal whiteness of the optic disc.

2. **Inflammation of the retina** (*Retinitis*).—This affection occurs in various forms, the most familiar of which is **Albuminuric retinitis.** This consists of a chronic inflammation, apparently commencing in the arteries and accompanied by hæmorrhages and degenerations of the retinal and choroid tissue. The affection of the arteries consists in an inflammatory thickening or sclerosis of their wall, with diminution in their calibre. The hæmorrhages are mostly in the superficial fibrous layer of the retina. Pale white spots and streaks in the region of the macula are very characteristic of the condition, and these arise chiefly by fatty degeneration. The hæmorrhagic spots may become white, but many spots are white from the first and not hæmorrhagic.

The affection of the retina occurs in cases of chronic Bright's disease. Diabetes, lead poisoning, etc., sometimes induce a retinitis essentially similar to the albuminuric form. It would seem that a grave alteration of the blood is the cause of the affection of the retina.

Pigmentary retinitis (*Retinitis pigmentosa*) is a form in which the choroid is involved along with the retina. It is a chronic inflammation or sclerosis, and the pigment cells seem to undergo local enlargement and increase so as to project into the retina and form dark patches. These patches follow the lines of the vessels.

3. **Embolism of the retinal artery.**—The central artery of the retina enters the eyeball in the middle of the optic nerve and then divides into branches which radiate from this centre. The artery is a branch of of the anterior cerebral artery, and it and its branches are end-arteries. Embolism is met with in cases of valvular disease of the heart. There is sudden blindness, which is usually permanent at least to the extent of the portion of the retina corresponding with the distribution of the occluded artery. The retina in the area affected undergoes necrosis and softening, this process being sometimes accompanied by hæmorrhage. Ultimately the optic nerve becomes atrophied.

Thrombosis of the retinal artery or vein is also known to occur.

4. **Detachment of the retina.**—In this condition the retina is separated from the choroid over a large or small area, and the separation is usually permanent. It may be caused by shrinking of the vitreous and by effusion of fluid between the choroid and the retina. It is also produced by injuries and by tumours, but it may occur without assignable cause.

IX. **Affections of the eye as a whole.**—Some of the diseases already mentioned affect the eyeball generally, and there are some affections which do so primarily.

1. **Sympathetic ophthalmitis.**—In wounds of the eye there is occasionally an extension of the inflammation to the opposite eye, and this is commonly spoken of as by sympathy. Inflammation, especially in the severe forms which sometimes occur, can scarcely owe its origin to nervous influences alone, and this conclusion is confirmed by the fact that the inflammation may progress after the eye primarily affected has been removed. Mackenzie first suggested that the inflammation travelled up the optic nerve to the chiasma and down the other nerve to the opposite eyeball. This view has been recently amplified, and it has been asserted that microbes extend up the sheath of one optic nerve and down that of the other so as to produce the inflammation. This would explain how the affection of the second eye always occurs considerably after that of the first, and how removal of that primarily affected does not always stop the disease. One of the principal difficulties in the way of accepting it is that the inflammation does not begin in the optic nerve and retina but in the ciliary body and iris. The explanation seems, however, generally accepted for cases of severe inflammation, but slighter inflammations and functional irritations of the eye may be produced reflexly.

The inflammation begins in the iris and ciliary body, and has generally the characters of an iritis and cyclitis. Predisposition or susceptibility seems to have considerable influence in determining the occurrence of sympathetic inflammation.

2. **Errors of accommodation.**—Vision is brought about by the images of objects being focussed on the retina. The focussing is effected by the refracting media of the eye, chiefly the lens and the cornea. In order to obtain accurate vision the image must fall in perfect focus on the retina. Variations in the focussing required by the greater or lesser distance of objects are brought about by the ciliary muscles acting on the lens. The condition of perfectly normal vision is designated **Emmetropia.** As life goes on the activity of the muscles and the elasticity of the lens lessen, and the power of rapid accommodation diminishes. This condition is called **Presbyopia.** The defective

power of accommodation is supplied by convex glasses. Other defects of vision occur when the image falls behind or in front of the retina, or is distorted.

In **Hypermetropia** the image falls behind the retina. This is usually due to abnormal shortness of the eyeball, but may also result from the refractive structures being deficient. Vision is good for distant objects but defective for near. In **Myopia** the image falls in front of the retina. The axis of the globe is usually too long for the refractive structures (axial myopia), but sometimes the refractive structures are too powerful (refractive myopia). Vision is defective for long distances and good at short distances. In **Astigmatism** the image is distorted, from the refractive media, chiefly the cornea, varying in convexity at different meridians.

These various defects may lead to irritation and straining of the eye from the attempts to bring the image into focus.

3. **Tumours of the eyeball.**—There are two common forms of tumour, sarcoma and glioma.

Sarcoma springs in the majority of cases from the choroid, but may take origin in the ciliary body or iris. It is usually a spindle-celled tumour, and in the large majority of cases is pigmented. The unpigmented forms are usually round-celled. The sarcoma in its growth usually detaches the retina and encroaches on the vitreous humour. The eyeball is occupied by the tumour mass, which in course of time generally extends also into and through the sclerotic. The sarcoma is prone to generalization, and tumours, frequently pigmented, spring up in various organs.

Glioma takes origin in the retina. It consists of round cells in a fine reticulum. The cells may be so abundant as to make the tumour approach to the structure of the sarcoma. Two forms are described under the designations exophytum and endophytum, according as the tumour originates in the external or internal granular layer of the retina. The tumour retains the characters of the layer from which it has originated. It grows for a time in the retina, gradually enlarging and filling the globe. After a time it may involve the coats of the eyeball and extend through the sclerotic. Occasionally it extends by metastasis to distant organs. It is characterized by a bright yellow reflection seen through the pupil.

Epithelioma sometimes occurs in the eyeball, and usually originates at the junction of cornea and conjunctiva. It may also originate in the conjunctiva. Cancer sometimes takes origin in the lachrymal glands.

The conjunctiva is also liable to simple growths, the commonest being the papilloma, the most frequent seat of which is the junction of the cornea and conjunctiva.

4. **Parasites of the eye.—Cysticercus cellulosæ** (the scolex of tænia solium) is not very uncommon in the eye. Its usual seat is beneath the retina, which may become detached by its growth. Sometimes the parasite perforates the retina and becomes free in the vitreous, where it may be seen with the ophthalmoscope as a clear cyst, from which the head of the worm sometimes protrudes. A less frequent seat is the anterior chamber, where it may be free or attached to the iris. It is capable of protruding and withdrawing its head. The cysticercus also occurs in the orbit outside the eyeball.

The Echinococcus occasionally has its seat in the orbit.

B.—THE EAR.

The ear has intimate anatomical relations with various other parts, and in its diseases it is frequently associated with these parts. It is continuous externally with the skin; it is in communication by means of the Eustachian tube with the mucous membrane of the naso-pharynx; it is intimately related to the bones of the skull and to the dura mater and brain. For purposes of description the diseases of the ear are divided into those of the external, middle, and internal ears, but these parts being closely related in position are frequently affected by disease together.

I. **Affections of the external ear.**—The external ear consists of the auricle, external auditory canal, and tympanic membrane.

1. The **Auricle** is liable to various **congenital malformations**, ranging from almost entire absence to simple alterations in the usual outline. Supernumerary organs, generally rudimentary, are also met with. Inflammations of the skin, such as erysipelas and inflammatory skin eruptions, especially eczema, may extend to the auricle.

A more independent affection is the **Hæmatoma of the auricle** or **Othæmatoma.** This consists in a hæmorrhage between the cartilage of the auricle and the perichondrium, the latter being raised, but generally carrying with it pieces of cartilage. It usually arises from injury, but in some cases the injury is slight or absent, and the condition is spontaneous. This condition is so frequent in insane persons, more particularly in dementia paralytica, that the name **Insane ear** is often used. The concavities of the auricle are filled out with the effused blood, which generally remains fluid for a considerable time. With the absorption of the blood there is generally marked shrinking and cicatricial contortion of the auricle. Sometimes injuries induce a serous exudation instead of blood, the condition otherwise resembling hæmatoma.

Small **Fibromas** sometimes form in the auricle in consequence of the irritation of earrings. **Gouty tophi** often occur in the cartilage of the auricle.

Epithelioma is not infrequent in the auricle. It occurs both in the form of flat-celled epithelioma and of rodent ulcer. The tumour which sometimes develops on a pre-existing eczema is liable to extend to the external meatus.

2. The **External auditory canal.**—Congenital contraction and closure of the canal have been observed in various degrees.

Inflammations are similar to those of the skin, and may be either in the form of boils, which are somewhat frequent, or of a diffuse inflammation. The former have the characters of cutaneous boils, with which they may be associated; the latter result chiefly from injuries, but also from the acute exanthemata, chiefly small-pox, from erysipelas, and from ordinary skin eruptions. The disease may extend to the osseous wall of the canal and lead to caries or necrosis, but these are more frequently the consequences of affections of the middle ear. In more chronic cases we have the usual new-formation of tissue of chronic inflammations, resulting in thickenings of the cutaneous lining of the canal and in some cases in hyperostosis, which may greatly contract the canal.

Exostoses not infrequently spring from the osseous wall.

Accumulations of cerumen very frequently occur to such an extent as to occlude the canal and cause deafness. They are usually dry and are composed of cerumen mixed with epidermis, hair, dust, etc. The accumulation is due either to excessive secretion or to some impediment to the escape of the wax.

Foreign bodies and **Parasites** are met with in the meatus. The former consist of a great variety of materials introduced from without and met with chiefly in children. Insects and their larvæ are occasionally found in the ear, the latter chiefly in cases where purulent discharge exists. The acarus folliculorum also occurs.

Fungi belonging to the family of the Aspergillus have been frequently observed growing in the meatus, chiefly in its inner recesses and on the tympanic membrane. They cause obstruction of the canal and may give rise to serious inflammations.

3. The **Tympanic membrane** is liable to **Inflammations** in common with the meatus on the one hand and the middle ear on the other. Hence arise various thickenings and adhesions, sometimes with cal-

careous deposition, chiefly in connection with diseases of the middle ear. Hence also arise **Perforations** of the membrane, which have frequently serious consequences for the tympanic cavity. **Rupture** is of occasional occurrence, usually in consequence of condensation of the air in the external meatus as from a blow on the ear, but also from instruments thrust into the ear.

II. **Affections of the middle ear.**—The middle ear is a cavity containing air, of a very complicated outline (see Fig. 726). The central part is that immediately within the tympanic membrane, forming the tympanic cavity, which is traversed by the chain of ossicula. From the lower and anterior part of this cavity passes the Eustachian tube down to the naso-pharynx. The upper and posterior part of the cavity communicates with the mastoid cells. The largest of these spaces lies immediately behind the tympanic cavity, of which it is almost a continuation backwards. This is the antrum mastoideum, the roof of which, along with that of the tympanic cavity, is formed by a thin layer of bone, which alone separates these cavities from the dura mater lining the middle fossa of the skull. The remaining mastoid cells communicate directly or indirectly with the antrum. In childhood the antrum is well developed, but the other cells are very imperfect, the mastoid process being small. The roofs of the tympanum and antrum are not infrequently deficient, especially in childhood, so that there are gaps in the osseous wall. The mucous membrane of the middle ear is, in most parts, very delicate, and is covered with a single layer of epithelium. In its structure and in the character of its epithelium it resembles a serous membrane. It is particularly thin over the ossicula and the

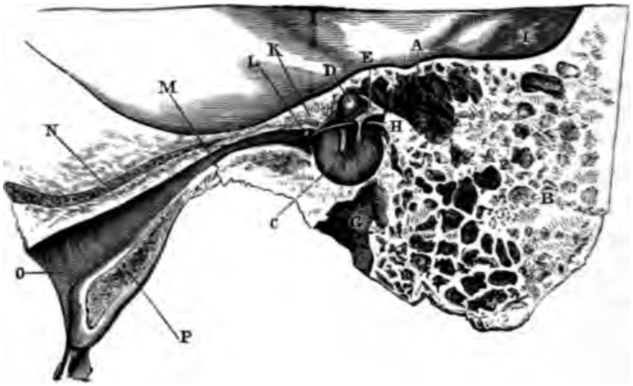

Fig. 726.—Section through the middle ear. A, antrum mastoideum; B, mastoid cells; C, inner surface of tympanic membrane; G, fossa for jugular vein; H, partition between tympanum and antrum; I, dura mater; L, tympanic aperture of Eustachian tube; O, pharyngeal mouth of same. (BARR.)

membrana tympani and in the mastoid cells. In the greater part of its extent the mucous membrane covers bone, and is inseparably united with the periosteum.

1. **Inflammations of the middle ear.**—These have characters similar to inflammation elsewhere, only modified by the relation of parts. **Catarrh** is somewhat common, and may be acute, subacute, or chronic. The exudation varies according to the severity of the inflammation, being mucous or muco-purulent. The catarrh may be localized mainly in the Eustachian tube, which may be obstructed by the swelling of the mucous membrane. The exudation may distend the tympanic cavity and cause bulging of the membrane. It will also interfere with the movements of the ossicula.

Chronic inflammations also occur which have little of the catarrhal character, but rather that of a chronic proliferative inflammation. These conditions are sometimes described as **Chronic, dry** or **adhesive catarrh**. They are associated with **Adhesions** and **Sclerosis** of the mucous surfaces. The inflamed surfaces are thickened, and wherever they come in contact they tend to coalesce. In this way fibrous adhesions are formed which may unite the membrana tympani or the ossicula to the opposite wall of the cavity. Like other connective tissues formed in inflammations this has a tendency to shrink and become dense, a process expressed in the term sclerosis. The pliant mucous membrane thus becomes rigid, and stiffens the membrana tympani, the ossicula, and the membrane of the fenestra rotunda. There is in some cases a new-formation of bone, so that thickenings and projections of the osseous wall of the cavity occur. There is not infrequently in the dense shrunken tissue a deposition of lime salts, a **Calcification** similar to that so frequently seen in chronic endocarditis. All these changes, by rendering rigid the structures concerned in propagating the sonorous vibrations, contribute to the causation of deafness.

Acute suppurative inflammation of the middle ear is a frequent result of scarlet fever, and more rarely of the other acute fevers. In these cases it arises by propagation upwards of an acute phlegmonous inflammation from the pharynx. In some cases the affection is ascribed to cold and ordinary catarrh of the nares or naso-pharynx, and in these the nature of the irritant is obscure. There is an acute inflammation of the mucous membrane going on to suppuration and always resulting in **Perforation of the membrana tympani**. The middle ear is, in fact, converted into a kind of abscess cavity and the pus finds its way out through the membrane. The inflammation may extend partly to the external and internal ears. The perforated membrane may afterwards heal, but in many cases there is considerable destruction of tissue, and when the inflammation subsides a permanent gap is left in the membrane, sometimes involving its entire extent.

Chronic suppurative inflammation of the middle ear, or **Otorrhœa** is a common result of the acute disease. The perforation of the membrana tympani, brought about in the way mentioned above, has far-reaching consequences. The mucous membrane of the middle ear thus becomes exposed to varied influences from without. It is liable to catarrhs, and, as the resulting exudation is exposed to the air, septic changes readily occur in it. The consequence of these septic changes is a suppurative inflammation, which, when once fully established, is likely to be permanent. The septic discharges lingering in all the complicated parts of the middle ear keep up the inflammation. The discharges are, consequently, in many cases exceedingly putrid. The mucous membrane is by degrees converted into a succulent granulation tissue from the vessels of which pus exudes. Various important consequences are liable to occur in this condition, such as polypi, caries, and abscess of the brain.

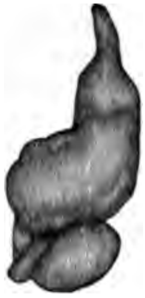

Fig. 727.—Large mucous polypus, which dilated the external auditory canal and protruded from the external orifice. (BARR.)

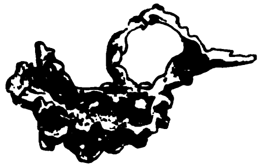

Fig. 728.—Sequestrum consisting of the annulus tympanicus and part of the mastoid process, removed from a child. (BARR.)

Mucous polypi are here, as in other places, outgrowths of vascular tissue from the inflamed mucous membrane (see Fig. 727). They protrude through the perforation in the membrane, into the meatus, and may even present at the external orifice. They are usually single mucous polypi, consisting of a very cellular connective tissue, in which mucous glands, sometimes forming cysts, may be present. They are more rarely fibrous in structure, and in that case contain no glands. A polypoid myxoma is an exceedingly rare form.

Caries and **Necrosis** of the underlying bone not infrequently occur. There may be gradually advancing inflammation of the bone, leading to erosion by a process of rarefying ostitis. Thus a considerable erosion of the temporal bone may ensue. In other cases necrosis of considerable portions of the temporal bone results, the dead bone being perhaps discharged (see Fig. 728). These processes are most liable to occur in the mastoid cells, where the discharges readily lie and decompose. In these parts the inflammation may, after a time, become acute, so that something in the nature of an abscess may form and come to the surface of the mastoid process.

Sometimes the suppuration extends outside rather than inside the mastoid process, so that there is a suppurative periostitis over this process, but without necrosis or caries.

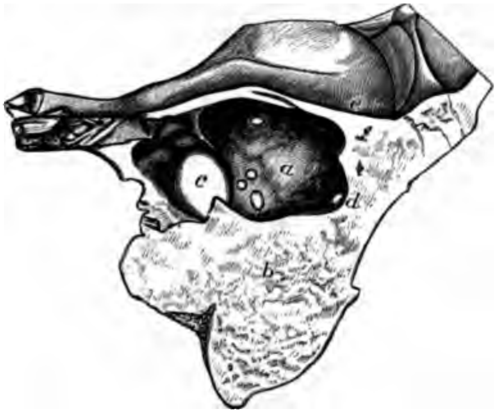

Fig. 729.—Section showing the effects of prolonged otorrhœa. *a*, enlarged antrum mastoideum; *b*, mastoid cells replaced by dense bone like ivory; *c*, tympanic cavity. The patient (a man) died of purulent meningitis. (BARR.)

In some cases there may be a **Formative ostitis**, so that new-formation of bone occurs, leading to thickenings, and sometimes to condensation of the cancellated mastoid structures (see Fig. 729). This may even occur coincidently with caries and necrosis, a rarefying and a condensing ostitis co-existing here as in other cases.

If **Healing** occurs in this disease there are liable to be the consequences of chronic inflammation already referred to. Healing will only occur if septic decomposition is got rid of. Unless the tympanic membrane closes, which it sometimes does by cicatricial new-formation, there is apt, at intervals, to be a renewal of the septic process and of the suppuration.

From the nearness of the structures concerned to the dura mater and brain, there is occasionally an **Extension of the septic process to the parts within the skull.** These consequences have already been referred to under Abscess of the Brain. They are chiefly **Septic**

thrombo-phlebitis, which may result in pyæmia, **Suppurative meningitis**, which may be associated with thrombo-phlebitis, and **Abscess of the brain**, which may arise by thrombo-phlebitis but also occurs without this. Paralysis of the facial nerve occasionally results from extension to the Fallopian canal.

2. **Syphilis** and **Tuberculosis** of the middle ear. Syphilis is stated to cause in some cases a chronic inflammation with sclerosis as already described. Tuberculosis has often been suspected in cases of chronic otorrhœa, and the tubercle bacillus has been repeatedly observed in the discharge.

3. **Sebaceous tumours of the ear, Cholesteatoma.**—Under these names are included two very different conditions, one of them, which is excessively rare, is a true tumour such as occurs in the brain. Most cases of so-called sebaceous tumour are due to nothing more than accumulated and inspissated products of inflammation, namely pus, epithelium, and debris. These collections may attain a considerable size and extend into the auditory canal. There may be a deposition of crystals of cholestearine giving a glistening appearance to the mass.

III. **Affections of the internal ear.**—The internal ear, consisting of the labyrinth and the auditory nerve, is rarely the primary seat of disease, but is liable to be involved in affections of the middle ear on the one hand, and of the brain and its membranes on the other. It does, however, sometimes suffer directly from the effects of continuous loud noises (as in boilermakers) or from blows on the head. These lead to chronic inflammations of the structures. According to Ogston an inflammation of the labyrinth with effusion is not uncommon in gouty and rheumatic persons.

Inflammations of the middle ear by affecting the bone directly may lead to destruction, or in a less degree to thickenings and atrophies of the labyrinthine structures. Sometimes the base of the stapes, by pressing too firmly on the fenestra ovalis, causes increased pressure in the labyrinthine fluid and consequent atrophy of the nerve. The abnormal position of the stapes may be the result of inflammation or it may be produced by obstruction of the Eustachian tube.

Syphilis not infrequently attacks the labyrinth leading to thickenings and consequent injury to the nerve structures. It is said, also, that hæmorrhage and serous exudation sometimes result from syphilis. **Congenital syphilis** may attack the labyrinth, so that deafness often coincides with keratitis and iritis.

Meningitis (cerebro-spinal and perhaps tubercular), by extending to the acoustic nerve or labyrinth, may lead in children to such damage to the structures as to result in total deafness. This is stated to be an important cause of deaf-mutism. **Acute fevers**, especially scarlet fever and typhoid fever, sometimes cause inflammation of the labyrinth. **Mumps** has occasionally a similar effect.

Diseases of the brain and its membranes, such as tumours, abscesses, and inflammations, often involve the auditory nerve within the skull. The auditory centre in the brain may also be involved by local diseases such as embolism and hæmorrhage.

Affections involving the labyrinth and producing **Alterations in the fluid contents of the semicircular canals** are apt to produce subjective sensations of giddiness and sickness. This is due to the fact that these structures apparently exercise an important function in connection with the retention of the equilibrium of the body. The group of symptoms thus produced is included under the designation **Ménière's disease**. A minor degree of giddiness and sickness may be produced by syringing the ear with cold water, especially when the membrane is perforated.

Any interference with the labyrinth leads to deafness, and this may be absolute. If this occurs in children the condition of **Deaf-mutism** results. Deaf-mutism will occur when deafness has been produced in the infant, from whatever cause, whether an affection of the middle or internal ear.

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